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A
GEOLOGICAL RECONNAISSANCE
ACROSS THE
BITTERROOT RANGE AND CLEARWATER MOUNTAINS IN MONTANA AND IDAHO

BY

WALDEMAR LINDGREN

WASHINGTON
GOVERNMENT PRINTING OFFICE
1904

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there was established the present United States forest reserve, which embraces the larger part of the Clearwater drainage. During the last few years the reserve has been patrolled by Government rangers in order to prevent forest fires, which in the past have caused such destruction within this area, and in order to check the indiscriminate slaughter of wild game which has gone on during the last ten or fifteen years. The Bitterroot Valley has gradually been settled, and to-day its orchards and fields form one of the most attractive parts of Montana. In 1897 the Nez Perce Reservation, which had long been a barrier to the settlement of the lower Clearwater, was thrown open, and the high prairies between the Clearwater and the Snake have been transformed into a rich and important farming country.

MAPS AND LITERATURE.

Until a recent date the topography of the Clearwater Mountains was only imperfectly known. The first approximately reliable data are contained in the map of the Department of the Columbia issued in 1881 by the Engineer Corps, United States Army, which was compiled by Lieut. T. W. Symons. During 1897 Mr. J. B. Lippincott made, for the United States Geological Survey, a reconnaissance map of the newly created forest reserve, on the scale of 6 miles to the inch. This excellent work is the chief basis of the maps published since then and is also used in this paper, somewhat reduced in scale. Many of the photographs in this report were taken by Mr. Lippincott in 1897. In 1897-98 the Hamilton quadrangle (Montana and Idaho) was mapped by Messrs. S. S. Gannett, E. C. Barnard, and A. B. Searle for the United States Geological Survey. The map of this quadrangle includes the crest of the central part of the Bitterroot Range; it is published on the scale of 1:125000, or about 2 miles to 1 inch, and it has 100-foot contour intervals. These, together with the cadastral surveys of the United States General Land Office (General Land Office, Department of the Interior, map of Idaho, 1898) of the eastern and western margins of the area involved, form the basis of the maps accompanying this report. Pl. I, which shows the region covered by this reconnaissance, is compiled from the Geological Survey map by Lippincott and the Land Office map of Idaho. The contours west of the western boundary of the forest reserve were sketched by myself from numerous aneroid observations.

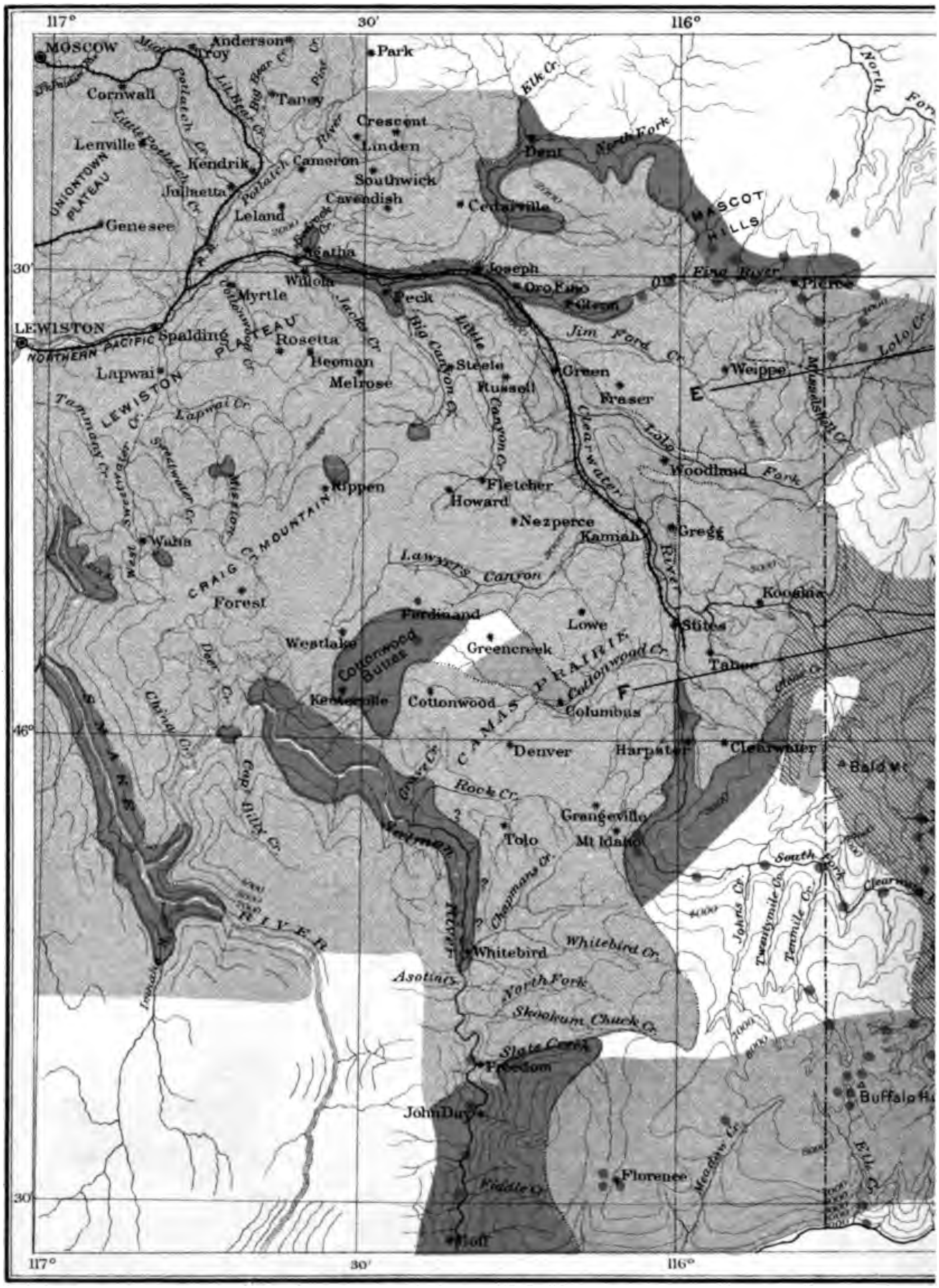
The reports dealing with the whole or parts of this region are as follows:

Russell, I. C., A reconnaissance in southeastern Washington: Water-Sup. and Irr. Paper No. 4, U. S. Geol. Survey, 1897.

Contains description of the canyon of Snake River below Lewiston.

Goode, R. U., The Bitterroot Forest Reserve: Nat. Geog. Mag., vol. 9, 1898, pp. 387-400, No. 9.

Contains general description of reserve and definition of mountain systems.



MAP OF CENTRAL IDAHO FROM

COMPILED FROM U.S. GEOLOGICA

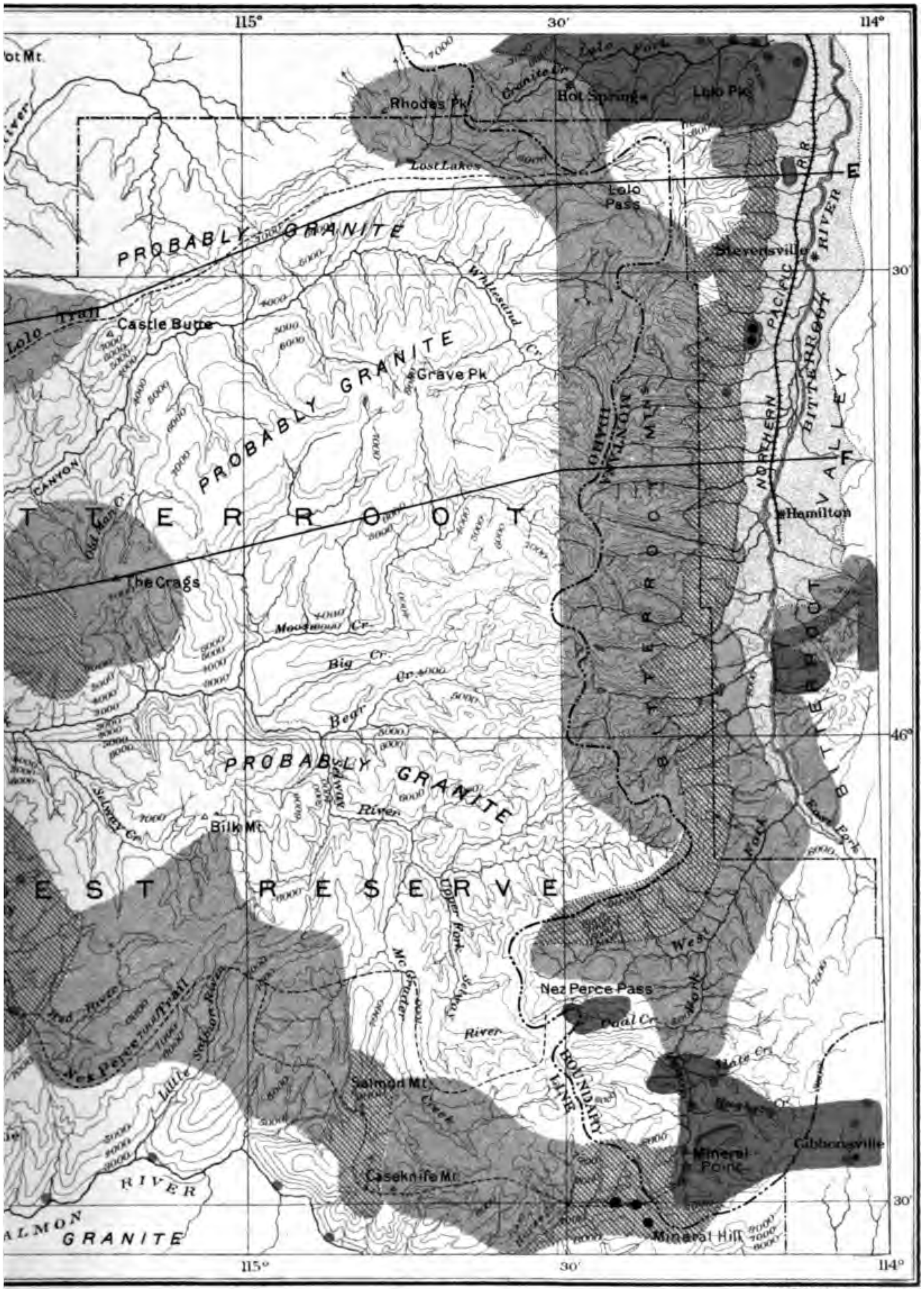
5 0 5
0 5 10 15

(Geological a

TERTIARY
(MIOCENE)

QUATERNARY

QUATERNARY		TERTIARY (MIOCENE)		
▢	■	■	▨	■
River deposits *(sands and gravels)*	**Prominent moraines**	**Rhyolite**	**Basalt** *(Columbia River lava)*	**Sedimentary r with schists eruptive mas**



ON TO THE BITTERROOT RANGE

D GENERAL LAND OFFICE MAPS

Profiles along the lines E-E and F-F are shown on Plate IV.

20 25 30 miles

5 40 45 50 kilometers

ı value only)

ERTIARY

▇ ıeiss

▇ Granite, quartz-monzonite and diorite

● Gold deposits. *(placers and veins)*

● Copper-silver deposits

● Silver-lead deposits

City and Buffalo Hump; thence across the high prairie south of Lewiston, up the main fork of the Clearwater to the Crags; finally, to Pierce and up to Rocky Ridge on the Lolo trail. Many parts of the area were not visited and the whole examination partakes of the character of a rapid reconnaissance. Fortunately, the route was laid out in a manner to obtain, in spite of this, a fairly accurate conception of the general geological structure of the whole region.

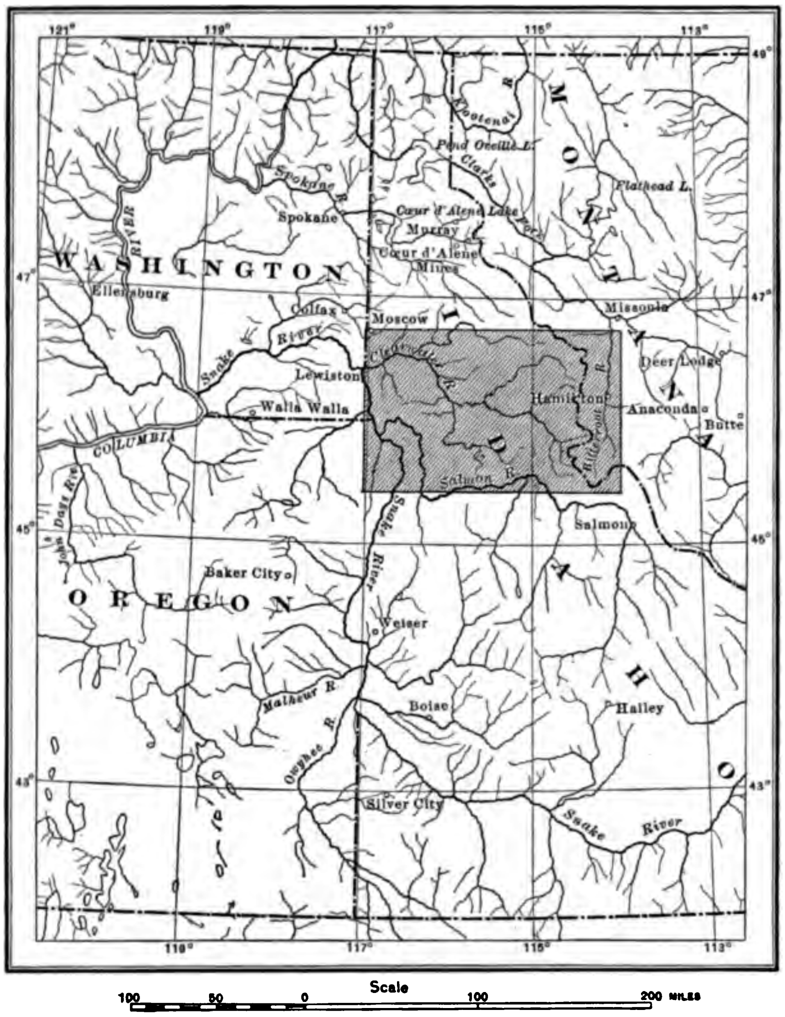


FIG. 1.—Index map showing extent of reconnaissance.

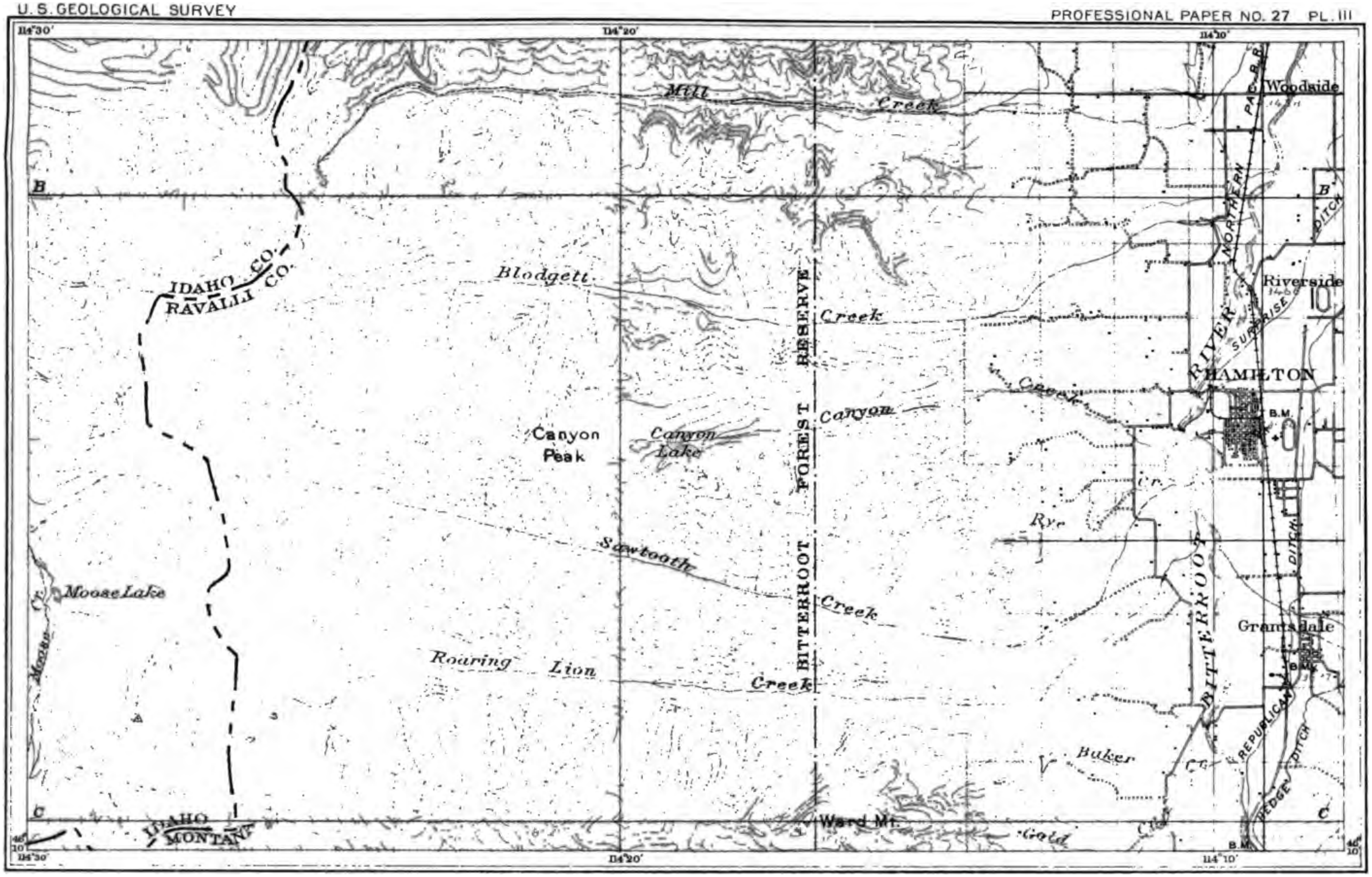
TOPOGRAPHY.

The nomenclature of the main ranges in these parts of Idaho and Montana is not yet settled, and it will, therefore, first be necessary to define the mountain systems involved. The whole area lies in the watershed of the Columbia River.

head of Bitterroot River, near the North Fork of the Salmon, and makes the Coeur d'Alene and Clearwater mountains subdivisions of this general term. On account of the strongly pronounced individuality of that part of the range between the Lolo and Nez Perce passes, which unquestionably has always been designated by the name of the "Bitterroot Range," I do not like to accept so wide a definition.

The Clearwater Mountains thus form a part of the great mountain region of central Idaho, a vast uplift extending from the Snake River Valley on the south well up toward the British possessions on the north. Like the Salmon River Mountains on the south and the Coeur d'Alene Mountains on the north, they are deeply dissected by a canyon system of rarely equaled extent and depth. The principal ridges between the streams, generally broad and flat, but sometimes also dissected into sharper crests and peaks, attain throughout about the same elevation, averaging perhaps 7,000 feet, and varying between 8,000 and 6,000 feet. Their combined crest lines would form an undulating plain differing little in elevation in the various parts of the Clearwater Mountains; in other words, sloping very little, if any, in any given direction. From their westerly margin the mountains slope rapidly to the lava plateau, which has an elevation of 3,000 to 3,500 feet. Along the Salmon River the high mountain plateau extends farther westward, and its last ramparts overlook the great bend of that river, rising 6,500 feet above its water line. The plateau character of the combined ridge lines is clearly seen in figs. 4 and 6 (pp. 60, 69). We must regard this surface as the result of erosion. The country was worn down to a comparatively gentle topographic feature, then uplifted and deeply dissected by canyons. Foremost of these is the great canyon of the Salmon, which, like a mighty V-shaped trench, is cut to a depth of from 4,000 to 5,000 feet practically across the whole width of Idaho, 100 miles in a straight line, and far more along the course of the river. It interposes a formidable obstacle to intercourse between the southern and northern parts of the State. Only one wagon road crosses it, and that can be traversed by only lightly loaded vehicles. Within a few miles of Snake River the Salmon bends suddenly northward and parallels the Snake for a distance of 40 miles, and then finally joins it, after making a wide curve convex toward the north. Until a point some distance below the great bend is reached the canyon is entirely cut in pre-Tertiary rocks and antedates the flows of the Columbia River lava. No bottom lands worthy of the name line the main part of the canyon, and many parts of the gorge are entirely inaccessible. Disaster has frequently overtaken those who have tried to navigate its wild rapids. The river is still largely eroding its bed. Below Freedom its course was changed by the Tertiary lavas.

The lower portion of the Clearwater River in the Columbia River lava closely parallels the Salmon, and its course is undoubtedly due to the same deter-



R U Goode Geographer in charge
Triangulation by S S Gannett
Topography by E C Barnard and A B Searle
Surveyed in 1897-98

CENTRAL PART OF BITTERROOT RANGE

FROM MAP OF HAMILTON QUADRANGLE

Scale
1 0 1 2 3 4 5 miles
Contour interval 100 feet
Datum is 31 feet above mean sea level

Julius Bien & Co N.Y.

Profiles along the lines BB and CC are shown on Plate IV

mining cause—that is, to the obstructing Tertiary flows of basalt. The Clearwater drainage system is much more branching, and though the trenches of the principal forks, the Lochsa and the Selway, are fully 4,000 feet deep and often inaccessible along the stream beds, they lack the grandeur of the single canyon of the Salmon. As seen from the map (Pl. I), the Clearwater splits in a number of branches, and, in fact, drains practically the whole area discussed in this paper. When the river enters the plateau of Columbia River lava the canyons are much less deep, but are much more sharply incised than the flaring trenches of the Clearwater Mountains.

Between the Lolo and Nez Perce passes, very close to the Montana boundary line, the mountains increase rapidly in elevation and form the narrow and sharply defined Bitterroot Range, which eastward soon slopes down to the equally pronounced depression of Bitterroot Valley.

The Bitterroot Range can best be likened to a long and narrow block raised 2,000 feet above the general elevation of the old Clearwater Plateau. North and south of it fragments of this plateau seem to continue for a still undetermined distance into Montana.

The Bitterroot River heads on the ridge north of the Salmon River Canyon. In its upper course, as far north as the southern end of the Bitterroot Range, the river and its branches have evidently dissected the same old Clearwater Plateau. It soon, however, enters the wide and level Bitterroot Valley and continues northward in this for over 60 miles. North of the mouth of Lolo Fork the bordering ridges again rise to the general level of the Clearwater Plateau. Gently sloping ridges face the Bitterroot Valley on the east, while on the west rises the high block of the Bitterroot Mountains, sloping down to the valley by a long, even declivity of 18°, and indicating by its geologic and topographic features its important tectonic character as a fault plane.

DESCRIPTIVE GEOLOGY.

GENERAL FEATURES.

SEDIMENTARY FORMATIONS.

In a broad way the distribution of the pre-Tertiary sedimentary formations in the region under consideration is as follows: Practically the entire area of the Bitterroot and Clearwater mountains is occupied by granite with some gneiss. West of the Clearwater River, and only imperfectly exposed below the lava, is an extensive sedimentary area adjoining this granite; smaller sedimentary areas are exposed on Lolo Fork and on the head of the South Fork of Bitterroot River. In no place have well-defined fossils been found, but there is some foundation for

the belief that the two last-named areas on the east side are very old, possibly pre-Cambrian, while the western area probably includes Triassic, Carboniferous, and possibly still older sediments.

The sedimentary series of the Lolo Fork, in the northeast corner of the area, consists of moderately metamorphosed quartzites, limestone, and banded slates, some of them of a purple color. This apparently conformable but evidently folded, overturned, and repeated series has a northwesterly or west-northwesterly strike and a prevailing northeasterly dip of 30° to 45°, and borders south and west against later granite with intrusive contact. The chief interest of this series lies in the fact that it is probably the southward end of the similar very extensive area which in the Coeur d'Alene section, 75 miles farther north, occupies the whole width of the Coeur d'Alene Mountains from the lake of the same name up to Mullan Pass, and thence down to the Clark Fork of the Columbia by way of St. Regis de Borgia River. Throughout, this Coeur d'Alene series has a west-northwest or northwesterly strike and usually a moderate northeasterly dip. No fossils have been found in it, and my belief is that it should be coordinated with the thick pre-Cambrian series of central Montana.

Small exposures of the same or a similar series are noted along the foothills of the Bitterroot Valley and again on the Skalkaho and Weeping Child Creek, where they also border intrusive granite.

A series of quartzites or quartzitic schists and slates occupies a considerable area at the very head of the South Fork of the Bitterroot and extends at least as far as Gibbonsville, Idaho, on the east. They appear to be thrown into flat folds dipping east or west at moderate angles. They are probably intruded by granite and certainly by granite-porphyry on the north, and border against older gneisses on the south.

At the western foot of the Clearwater Mountains the most prominent sedimentary terrane is composed of black slates, limestones, quartzitic slates, and associated partly schistose and probably effusive greenstones which are found on the South Fork of the Clearwater and which extend only a short distance north of Harpsters. This series has a persistent northeasterly strike and steep dip, and evidently forms the northern continuation of beds of the same strike exposed at intervals below the Columbia River basalt on the lower Salmon, in the Seven Devils, and, over 100 miles distant, near Huntington. Triassic fossils have been found in the Seven Devils,[a] and a large part of this long area of sediments is believed to be of Triassic age. Still farther west sedimentary rocks of unknown age, but probably Paleozoic or Mesozoic, are exposed near the junction of the Salmon and Snake rivers, in the Cottonwood Buttes, and in Clearwater Canyon

---

[a] Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 581.

composition: quartz is abundant in medium-size grains, while the feldspars are represented by both orthoclase and oligoclase, the latter usually in large quantity. Perthite is also frequently encountered, and more rarely microcline. The rock contains far too much oligoclase to be classed as a normal granite and should be rather characterized as a quartz-monzonite. Modifications more closely allied to granodiorite, diorite, and granite occur in subordinate quantity.

The granite is typically developed near the head of Mill Creek, Bitterroot Range, where it is a light-gray, medium-grained rock, with small foils of biotite and a little muscovite. A few larger crystals of orthoclase reach one-half inch in length. Under the microscope the rock shows much quartz, a little normal orthoclase, and many large grains of microperthite. An acidic oligoclase with very narrow striations is very abundant. Biotite and muscovite occur in scattered straight foils. Few accessories except zircon and apatite were noted, though titanite occurs abundantly in basic concretions in the same granite. The structure is typically granitic; the oligoclase is in part idiomorphic and sometimes included in the perthite. An analysis of this rock is given in the table below, together with such analyses of rocks as are available from the southern end of this great granitic batholith.

Analyses of granitic rocks from Idaho.

	I.	II.	III.	IV.	V.
SiO_2	72.07	69.56	68.42	65.23	57.78
Al_2O_3	15.51	15.29	15.01	16.94	16.28
Fe_2O_3	.31	.86	.97	1.60	1.02
FeO	1.01	2.06	1.93	1.91	4.92
MgO	.35	.69	1.21	1.31	4.60
CaO	1.93	2.81	2.60	3.85	6.65
Na_2O	4.02	3.97	3.22	3.57	3.25
K_2O	4.09	3.36	4.25	3.02	2.22
H_2O below 110° C	.03	[a] .86	.54	.18	.34
H_2O above 110° C	.30		.73	.88	.92
TiO_2	.16	.55	.50	.66	1.07
CO_2	None.		.20	.25	.15
P_2O_5	.11	.16	.13	.19	.30
S			.02		.02
NiO and CoO			None.		.02
MnO	Trace.		.06	Trace.	.15
BaO			.12	.19	.12
SrO			.03		.07
Li_2O			Trace.		Trace.
	99.89	100.17	99.94	99.78	99.88

[a] Loss on ignition.

I. Quartz-monzonite. Near head of Mill Creek, Bitterroot Range, Montana. W. F. Hillebrand, analyst.

II. Quartz-monzonite, No. 46, Boise collection. Shafer Butte, Boise County, Idaho. George Steiger, analyst. Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 82.

III. Quartz-monzonite, No. 25, Hailey collection. Democrat mine, near Hailey, Blaine County, Idaho. W. F. Hillebrand, analyst. Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 82.

IV. Granodiorite, No. 79, Boise collection. Silver Wreath tunnel, Willow Creek mining district, Boise County, Idaho. George Steiger, analyst. Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 82.

V. Diorite, No. 32, Hailey collection. Crœsus mine, near Hailey, Blaine County, Idaho. W. F. Hillebrand, analyst. Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, p. 82.

The approximately calculated composition of the rocks is as follows:

Calculated composition of rocks from Idaho.

	I.	II.	III.	IV.	V.
Quartz	28.73	28.04	29.21	25.00	8.45
Orthoclase molecule	20.04	15.84	18.07	11.21	7.57
Albite molecule	33.98	33.54	27.19	30.25	26.20
Anorthite molecule	8.36	11.15	9.53	13.88	20.45
Biotite[a]	[b]8.03	7.55	12.36	15.99	[c]32.55
Apatite	.27	.37	.47	.44	.69
Titanite	.29	1.13	.88	1.65	1.29
Magnetite	.17	.93	.31	.61	1.48
Calcite	....	....	.45	.57	.33
Pyrite	....	....	.03	....	.03
Hygroscopic water	.03	.36	.54	.18	.34
Excess combined water	....	.27	.32	....	.51
Total	99.90	99.18	99.36	99.78	99.89

[a] Molecular ratio assumed: $MgO: SiO_2: TiO_2: Al_2O_3: Fe_2O_3: FeO: CaO: K_2O: H_2O=1: 2.44: .06: .75: .14: .88: .04: .42: .76$.

[b] Biotite, 5.03; muscovite, 3.00. Molecular ratio of biotite in this analysis figures out to $MgO: SiO_2: Al_2O_3: Fe_2O_3: FeO: CaO: K_2O: H_2O: TiO_2=1: 3.64: 1.11: .14: 1.52: .04: .42: 1.04: .06$

[c] Biotite, diallage, hypersthene, hornblende.

The analysis of the rock from the Bitterroot Range shows so great similarity to II and III, both of which are representative rocks, that no special calculation seems necessary. It contains the same amount of quartz and a more sodic oligoclase, while the potash feldspar is slightly increased, a little muscovite being present in I. Analyses IV and V represent local basic modifications. The five analyses form a series with gradually lowered SiO_2, constant Al, and increasing Fe, Mg, Ca. The first three rocks should doubtless be considered as quartz-monzonites, though I distinctly approaches the granites.

In the Bitterroot Mountains streaks of basic magmatic segregations often appear, characterized by biotite and hornblende, quartz, orthoclase, oligoclase, [illegible] granite [illegible] pegmatite [illegible]

[illegible] the intrusive character of the granite [illegible] the same age and a geological unit. The age can not be determined with certainty on account of the absence of fossils in the surrounding formations. In the [illegible] part of the batholith [illegible] granite [illegible]

Dikes in granite.—In the [illegible] dikes are not common in the principal granite area [illegible] pegmatites and aplites [illegible]. In the eastern [illegible] of the Bitterroot Valley, however, and along the South Fork of Bitterroot River dikes of granite-porphyry and aplite are very abundant in the granite. The scattered gneiss areas of [illegible] Mountain, as well as the more extensive areas of Elk City, contain also an abundance of pegmatitic, granitic, and dioritic dikes. The gneiss is sometimes injected by a great number of narrow pegmatite dikelets which have suffered a crumpling at the same time as the surrounding foliated rocks.

GNEISS.[b]

In a prevailing terrane of intrusive granite the Bitterroot and the Clearwater mountains contain numerous areas of gneissoid rocks of very differing ages. Some are later than the granite, of which they indeed, are only a modification, caused by peculiarly applied stresses. If the conclusion as to the age of the granite is correct, these gneisses are post-Triassic. Others are of much greater age, being probably older than the associated sediments, which are themselves older than the granite. In these sediments no fossils have been found, and their true horizon is thus doubtful. Very likely, however, parts or all of this second series of gneisses may be of pre-Cambrian age.

The first and most extensive gneiss area is that which follows the well-marked eastern slope of the Bitterroots, and which is clearly nothing but a sheet

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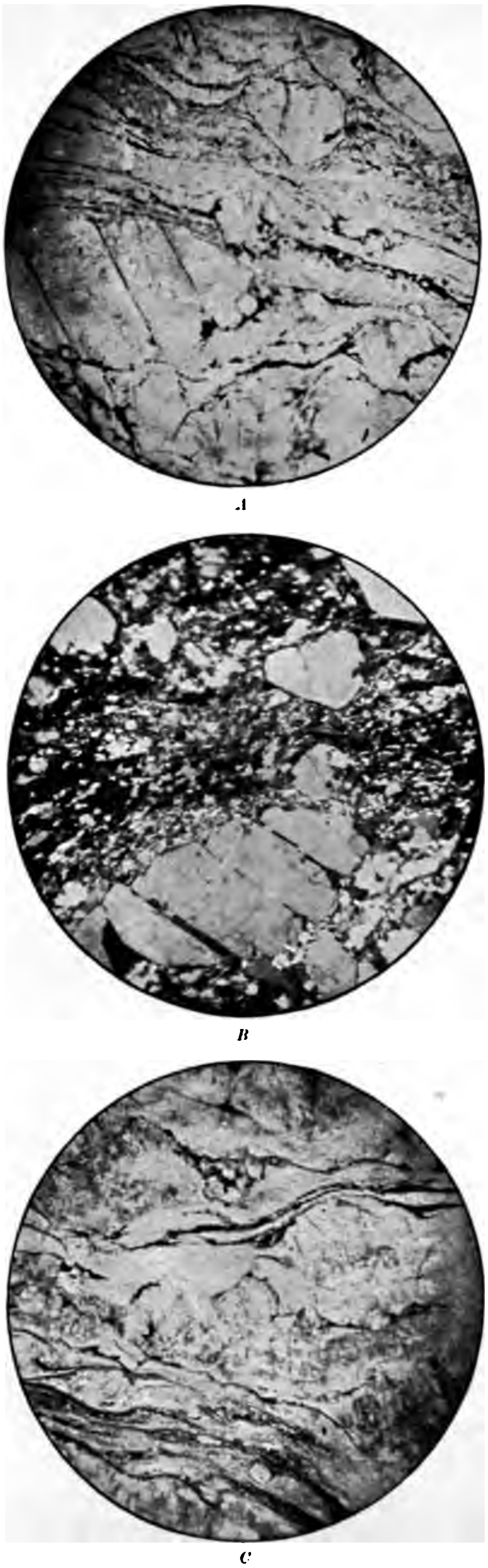
[a] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 79.

[b] The word gneiss is here used without limitations as to age and origin.



PHOTOMICROGRAPHS OF GNEISS OR GRANITE-SCHIST.

A, Gneiss or granite-schist from near mouth of Tin Cup Canyon; ordinary light, X 20.
B, Same as *A*; crossed nicols, X 20.
C, Gneiss or granite-schist from near mouth of Sawtooth Canyon; ordinary light, X 20.

of pressed and deformed granite. It is usually a light-gray, granular, and schistose rock, and consists of lenticular squeezed aggregates of oligoclase and quartz and deformed orthoclase crystals, separated by somewhat curved aggregates of new-formed biotite and muscovite. The primary constituents are the same as those of the granite. All transitions toward massive granite may be seen. Excessive compression results in finer-grained and darker micaceous schists. This gneiss is characterized by abundant slipping planes, which show movements parallel to the dip, and on which large plates of muscovite have often formed. As far as the observations showed, this gneiss is never crumpled and folded like the older gneisses.

The incipient gneissoid structure may be well observed in the gneissoid granite of Lost Horse Pass near Twin Lakes. (Pl. V.) Macroscopically it is light-gray granular rock of medium grain. The schistose structure is not prominent, but indicated by the distribution of the biotite and the lenticular shape of larger feldspar crystals. Under the microscope the large grains consist of quartz, orthoclase, and oligoclase, very similar to those in the normal granite. The biotite is largely recrystallized and converted to stringy aggregates of the same mineral partly changed into chlorite. Some muscovite is also present. There is an abundant development of new allotriomorphic fine-grained aggregates along winding and curving shearing planes. This aggregate consists of feldspar, mostly without striations, and quartz; there is also much micropegmatite, and in places a coarse poikilitic structure. Black iron ore in irregular, sometimes pressed, grains as well as apatite and zircon are accessories.

About halfway up Lost Horse Creek similar but more schistose rocks were observed. Their appearance under the microscope is similar to the specimens just described; in addition the larger grains are greatly crushed with much cataclastic structure. The normal gneiss from Mill Creek, 2 miles above the mouth of the canyon, is a plainly schistose rock with large orthoclase crystals pressed into partly lenticular shape. Biotite and a little muscovite lie in flat aggregates between streaks of pressed feldspar and quartz. There is much cataclastic action and formation of new allotriomorphic aggregates along wavy lines, which indicate schistosity. Large feldspar and quartz grains, when crossed by these lines, are greatly crushed. On the whole, however, the rock has great similarity to the normal Bitterroot granite.

Stronger crushing action near the mouth of the canyons simply results in emphasizing the characteristics already referred to. The sinuous lines along which most active recrystallizing movement is in progress multiply, and at last the whole rock is transformed into a fine-grained aggregate traversed by wavy streaks of finely distributed biotite and a little muscovite, and in this mass lie as [illegible] the irregular, more frequently lenticular remnants of larger grains. These are often cut by parallel cracks which dip about 30° E. and which are sometimes opened and filled by secondary quartz, suggesting a stretching movement.

Still further pressure results in dark, fine-grained bands in the coarser gneiss, which under the microscope appear to be [illegible] by extremely finely divided mosaic with allotriomorphic feldspar and quartz. This mass contains small rounded remnants of larger grains, and the whole imitates fairly successfully a fine-grained clastic rock.

The second gneiss area is that of St. Marys Peak in the northern corner of the range and probably underlying the sedimentary Lolo series. This dark-gray gneiss is very rich in black mica and weathers to reddish outcrops. It is usually crumpled and includes portions or streaks of exceedingly micaceous schists. The dip is usually steep toward the west. The origin of the rock is uncertain.

On the east side of the Bitterroot Valley the granite, which is presumably but not certainly of the same age as the normal Bitterroot granite, contains frequent, well-defined inclusions of a crumpled gneiss, like that of St. Marys Peak. It is believed that this gneiss is composed of fragments of a more extensive formation which had been shattered by the granite. In places the granite itself is somewhat schistose. Dip and strike of these roughly gneissoid rocks, as well as those of the inclusions, are characteristically variable.

The next big gneiss area is found at the very head of the South Fork of the Bitterroot, adjoining the quartzitic series of that valley, which probably is identical with that of the Lolo Fork; the contact, though difficult to interpret, probably indicates that the gneiss underlies the sedimentary formation. This gneiss, which is cut by many granite dikes, consists of medium-grained aggregates of quartz and feldspar with some larger deformed crystals of the same kind. The abundant aggregates of muscovite and biotite run in irregular bands, curving around the lenticular patches of quartz and feldspar. It is often contorted and sometimes of coarse grain. It contains much microcline and little plagioclase. The schistosity is variable, but most frequently it dips 40° E.

A similar gneiss area, perhaps connecting southward with the one just described, is found on Salmon Mountain; it is extensively broken and intruded by granite dikes. Both these areas are pretty surely dynamo-metamorphosed granitic rocks of much greater age than the Bitterroot granite.

A much larger gneiss area is that of Elk City. It is elliptical in form and extends 40 miles north and south and 24 miles east and west. It borders almost everywhere against granite, the contact plainly showing the intrusive nature of the latter rock. The gneiss of this area is uniform in character; it is of light-gray color, roughly schistose, and consists of a granular mass of white feldspar and quartz, occasionally with larger orthoclase crystals; the aggregates of biotite indicate the schistosity. Microscopically the rock was found to consist of quartz, much microcline, grains of oligoclase or andesine, together with much black mica and sometimes a little hornblende. Crumpling and folding perpendicular to the schistosity are usually characteristic. Intruded narrow dikes of granite or pegmatite have often suffered the same crumpling. This rock also is clearly a dynamo-metamorphic form of a very old granite. The dip is generally flat, but characteristically variable.

An area of gneiss with equally variable strike and dip and also adjoined by intrusive granite begins at Pierce. Similar rocks occur in the lower part of the canyon of the North Fork of the Clearwater and at Oro Fino, along the main stream. Mica-schists, sometimes garnetiferous, and (at Oro Fino) limestone beds also occur with gneissoid rocks and the series is probably made up partly of highly altered sedimentary rocks, partly of sheared intrusives, both older than the Bitterroot granite. The intense and equally distributed metamorphism of this series is probably not due to the adjoining granite, but rather to regional causes.

TERTIARY LAVAS.

The distribution of younger igneous rocks in this region is peculiar. A line of rhyolitic eruptions of moderate volume follows the Bitterroot Valley. No basalts or andesites are known to exist here. Within the whole extent of the Bitterroot and the Clearwater Mountains no surface lavas of any kind have been found, but at the foot of these same mountains is spread out a veritable flood of Miocene basalts, covering thousands of square miles. Neither rhyolites nor andesites are known from this part of the country.

Rhyolite.—Beginning at the north the first small area of rhyolite is found a few miles west of Florence in the Bitterroot Valley, forming a low ridge near the first foothills. Forty miles farther south a much larger area is exposed in the bluffs on the east side of the river, forming a succession of tuffaceous, vitreous, and felsitic flows several hundred feet thick. This rock breaks through the granite and gneiss of the eastern foothills and many long dikes in the vicinity indicate its manner of eruption.

Dikes of granite-porphyry, many of which have a somewhat rhyolitic habit, occur along the South Fork above the junction. Between Blue Joint and Overwhich creeks, well up toward the head of the stream, another not very thick rhyolite flow is met with, a small area still remaining on the summit of Crown Peak or Castle Rock south of Nez Perce Pass. It filled the bottom of the valley to a depth of several hundred feet. In its upper part sedimentary beds and lignite

mining cause—that is, to the obstructing Tertiary flows of basalt. The Clearwater drainage system is much more branching, and though the trenches of the principal forks, the Lochsa and the Selway, are fully 4,000 feet deep and often inaccessible along the stream beds, they lack the grandeur of the single canyon of the Salmon. As seen from the map (Pl. I), the Clearwater splits in a number of branches, and, in fact, drains practically the whole area discussed in this paper. When the river enters the plateau of Columbia River lava the canyons are much less deep, but are much more sharply incised than the flaring trenches of the Clearwater Mountains.

Between the Lolo and Nez Perce passes, very close to the Montana boundary line, the mountains increase rapidly in elevation and form the narrow and sharply defined Bitterroot Range, which eastward soon slopes down to the equally pronounced depression of Bitterroot Valley.

The Bitterroot Range can best be likened to a long and narrow block raised 2,000 feet above the general elevation of the old Clearwater Plateau. North and south of it fragments of this plateau seem to continue for a still undetermined distance into Montana.

The Bitterroot River heads on the ridge north of the Salmon River Canyon. In its upper course, as far north as the southern end of the Bitterroot Range, the river and its branches have evidently dissected the same old Clearwater Plateau. It soon, however, enters the wide and level Bitterroot Valley and continues northward in this for over 60 miles. North of the mouth of Lolo Fork the bordering ridges again rise to the general level of the Clearwater Plateau. Gently sloping ridges face the Bitterroot Valley on the east, while on the west rises the high block of the Bitterroot Mountains, sloping down to the valley by a long, even declivity of 18°, and indicating by its geologic and topographic features its important tectonic character as a fault plane.

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In a broad way the distribution of the pre-Tertiary sedimentary formations in the region under consideration is as follows: Practically the entire area of the Bitterroot and Clearwater mountains is occupied by granite with some gneiss. West of the Clearwater River, and only imperfectly exposed below the lava, is an extensive sedimentary area adjoining this granite; smaller sedimentary areas are exposed on Lolo Fork and on the head of the South Fork of Bitterroot River. In no place have well-defined fossils been found, but there is some foundation for

the belief that the two last-named areas on the east side are very old, possibly pre-Cambrian, while the western area probably includes Triassic, Carboniferous, and possibly still older sediments.

The sedimentary series of the Lolo Fork, in the northeast corner of the area, consists of moderately metamorphosed quartzites, limestone, and banded slates, some of them of a purple color. This apparently conformable but evidently folded, overturned, and repeated series has a northwesterly or west-northwesterly strike and a prevailing northeasterly dip of 30° to 45°, and borders south and west against later granite with intrusive contact. The chief interest of this series lies in the fact that it is probably the southward end of the similar very extensive area which in the Coeur d'Alene section, 75 miles farther north, occupies the whole width of the Coeur d'Alene Mountains from the lake of the same name up to Mullan Pass, and thence down to the Clark Fork of the Columbia by way of St. Regis de Borgia River. Throughout, this Coeur d'Alene series has a west-northwest or northwesterly strike and usually a moderate northeasterly dip. No fossils have been found in it, and my belief is that it should be coordinated with the thick pre-Cambrian series of central Montana.

Small exposures of the same or a similar series are noted along the foothills of the Bitterroot Valley and again on the Skalkaho and Weeping Child Creek, where they also border intrusive granite.

A series of quartzites or quartzitic schists and slates occupies a considerable area at the very head of the South Fork of the Bitterroot and extends at least as far as Gibbonsville, Idaho, on the east. They appear to be thrown into flat folds dipping east or west at moderate angles. They are probably intruded by granite and certainly by granite-porphyry on the north, and border against older gneisses on the south.

At the western foot of the Clearwater Mountains the most prominent sedimentary terrane is composed of black slates, limestones, quartzitic slates, and associated partly schistose and probably effusive greenstones which are found on the South Fork of the Clearwater and which extend only a short distance north of Harpsters. This series has a persistent northeasterly strike and steep dip, and evidently forms the northern continuation of beds of the same strike exposed at intervals below the Columbia River basalt on the lower Salmon, in the Seven Devils, and, over 100 miles distant, near Huntington. Triassic fossils have been found in the Seven Devils,[a] and a large part of this long area of sediments is believed to be of Triassic age. Still farther west sedimentary rocks of unknown age, but probably Paleozoic or Mesozoic, are exposed near the junction of the Salmon and Snake rivers, in the Cottonwood Buttes, and in Clearwater Canyon

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[a] Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 581.

City and Buffalo Hump; thence across the high prairie south of Lewiston, up the main fork of the Clearwater to the Crags; finally, to Pierce and up to Rocky Ridge on the Lolo trail. Many parts of the area were not visited and the whole examination partakes of the character of a rapid reconnaissance. Fortunately, the route was laid out in a manner to obtain, in spite of this, a fairly accurate conception of the general geological structure of the whole region.

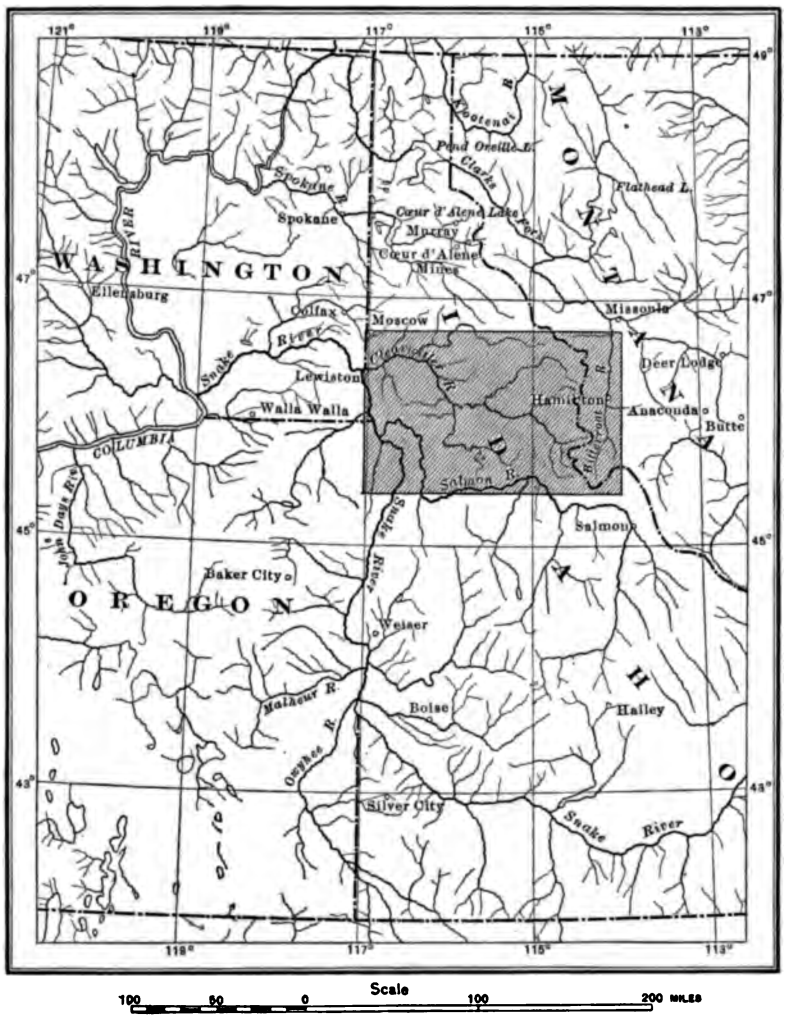

FIG. 1.—Index map showing extent of reconnaissance.

TOPOGRAPHY.

The nomenclature of the main ranges in these parts of Idaho and Montana is not yet settled, and it will, therefore, first be necessary to define the mountain systems involved. The whole area lies in the watershed of the Columbia River.

head of Bitterroot River, near the North Fork of the Salmon, and makes the Coeur d'Alene and Clearwater mountains subdivisions of this general term. On account of the strongly pronounced individuality of that part of the range between the Lolo and Nez Perce passes, which unquestionably has always been designated by the name of the "Bitterroot Range," I do not like to accept so wide a definition.

The Clearwater Mountains thus form a part of the great mountain region of central Idaho, a vast uplift extending from the Snake River Valley on the south well up toward the British possessions on the north. Like the Salmon River Mountains on the south and the Coeur d'Alene Mountains on the north, they are deeply dissected by a canyon system of rarely equaled extent and depth. The principal ridges between the streams, generally broad and flat, but sometimes also dissected into sharper crests and peaks, attain throughout about the same elevation, averaging perhaps 7,000 feet, and varying between 8,000 and 6,000 feet. Their combined crest lines would form an undulating plain differing little in elevation in the various parts of the Clearwater Mountains; in other words, sloping very little, if any, in any given direction. From their westerly margin the mountains slope rapidly to the lava plateau, which has an elevation of 3,000 to 3,500 feet. Along the Salmon River the high mountain plateau extends farther westward, and its last ramparts overlook the great bend of that river, rising 6,500 feet above its water line. The plateau character of the combined ridge lines is clearly seen in figs. 4 and 6 (pp. 60, 69). We must regard this surface as the result of erosion. The country was worn down to a comparatively gentle topographic feature, then uplifted and deeply dissected by canyons. Foremost of these is the great canyon of the Salmon, which, like a mighty V-shaped trench, is cut to a depth of from 4,000 to 5,000 feet practically across the whole width of Idaho, 100 miles in a straight line, and far more along the course of the river. It interposes a formidable obstacle to intercourse between the southern and northern parts of the State. Only one wagon road crosses it, and that can be traversed by only lightly loaded vehicles. Within a few miles of Snake River the Salmon bends suddenly northward and parallels the Snake for a distance of 40 miles, and then finally joins it, after making a wide curve convex toward the north. Until a point some distance below the great bend is reached the canyon is entirely cut in pre-Tertiary rocks and antedates the flows of the Columbia River lava. No bottom lands worthy of the name line the main part of the canyon, and many parts of the gorge are entirely inaccessible. Disaster has frequently overtaken those who have tried to navigate its wild rapids. The river is still largely eroding its bed. Below Freedom its course was changed by the Tertiary lavas.

The lower portion of the Clearwater River in the Columbia River lava closely parallels the Salmon, and its course is undoubtedly due to the same deter-

mining cause—that is, to the obstructing Tertiary flows of basalt. The Clearwater drainage system is much more branching, and though the trenches of the principal forks, the Lochsa and the Selway, are fully 4,000 feet deep and often inaccessible along the stream beds, they lack the grandeur of the single canyon of the Salmon. As seen from the map (Pl. I), the Clearwater splits in a number of branches, and, in fact, drains practically the whole area discussed in this paper. When the river enters the plateau of Columbia River lava the canyons are much less deep, but are much more sharply incised than the flaring trenches of the Clearwater Mountains.

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composition; quartz is abundant in medium-size grains, while the feldspars are represented by both orthoclase and oligoclase, the latter usually in large quantity. Perthite is also frequently encountered, and more rarely microcline. The rock contains far too much oligoclase to be classed as a normal granite and should be rather characterized as a quartz-monzonite. Modifications more closely allied to granodiorite, diorite, and granite occur in subordinate quantity.

The granite is typically developed near the head of Mill Creek, Bitterroot Range, where it is a light-gray, medium-grained rock, with small foils of biotite and a little muscovite. A few larger crystals of orthoclase reach one-half inch in length. Under the microscope the rock shows much quartz, a little normal orthoclase, and many large grains of microperthite. An acidic oligoclase with very narrow striations is very abundant. Biotite and muscovite occur in scattered straight foils. Few accessories except zircon and apatite were noted, though titanite occurs abundantly in basic concretions in the same granite. The structure is typically granitic; the oligoclase is in part idiomorphic and sometimes included in the perthite. An analysis of this rock is given in the table below, together with such analyses of rocks as are available from the southern end of this great granitic batholith.

Analyses of granitic rocks from Idaho.

	I.	II.	III.	IV.	V.
SiO_2	72.07	69.56	68.42	65.23	57.78
Al_2O_3	15.51	15.29	15.01	16.94	16.28
Fe_2O_3	.31	.86	.97	1.60	1.02
FeO	1.01	2.06	1.93	1.91	4.92
MgO	.35	.69	1.21	1.31	4.60
CaO	1.93	2.81	2.60	3.85	6.65
Na_2O	4.02	3.97	3.22	3.57	3.25
K_2O	4.09	3.36	4.25	3.02	2.22
H_2O below 110° C	.03	[a].86	.54	.18	.34
H_2O above 110° C	.30		.73	.88	.92
TiO_2	.16	.55	.50	.66	1.07
CO_2	None.		.20	.25	.15
P_2O_5	.11	.16	.13	.19	.30
S			.02		.02
NiO and CoO			None.		.02
MnO	Trace.		.06	Trace.	.15
BaO			.12	.19	.12
SrO			.03		.07
Li_2O			Trace.		Trace.
	99.89	100.17	99.94	99.78	99.88

[a] Loss on ignition.

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CaO	1.93	2.81	2.60	3.85	6.65
Na_2O	4.02	3.97	3.22	3.57	3.25
K_2O	4.09	3.36	4.25	3.02	2.22
H_2O below 110° C	.03	[a].86	.54	.18	.34
H_2O above 110° C	.30		.73	.88	.92
TiO_2	.16	.55	.50	.66	1.07
CO_2	None.	....	.20	.25	.15
P_2O_5	.11	.16	.13	.19	.30
S	....	....	.02	....	.02
NiO and CoO	....	....	None.	....	.02
MnO	Trace.	....	.06	Trace.	.15
BaO	....	....	.12	.19	.12
SrO	....	....	.03	....	.07
Li_2O	....	....	Trace.	....	Trace.
	99.89	100.17	99.94	99.78	99.88

[a] Loss on ignition.

and andesine, together with much titanite. Almost normal granites with prevailing orthoclase were observed west of Little Salmon Meadows and on the head of Crooked River. Dioritic modifications were observed near the schist contact at Pierce, and in the Clearwater Canyon near Greers Ferry. At the latter place a very fine diorite-pegmatite, consisting of hornblende and a plagioclase of medium acidity, is exposed in a railroad cut near the river.

Age.—The intrusive character of the granitic batholith is apparent at all places where it adjoins adjacent formations. The petrographic character is, on the whole, so constant that it seems probable that the whole area is of the same age, and a geological unit. The age can not be determined with certainty on account of the absence of fossils in the surrounding formations. In the southern part of the batholith, near Hailey, on Wood River, it has been shown that the intrusion is certainly post-Carboniferous.[a] As it has been shown (p. 16) that the sedimentary series on the South Fork of the Clearwater, near Harpster, is very probably Triassic, a post-Triassic age may, with the same degree of certainty, be attributed to the great granitic batholith.

Dikes in granite.—On the whole, dikes are not common in the principal granite area embraced in this report, even pegmatites and aplites being rare. In the eastern foothills of the Bitterroot Valley, however, and along the South Fork of Bitterroot River dikes of granite-porphyry and rhyolite are very abundant in the granite. The shattered gneiss areas of Horse Creek and Salmon Mountain, as well as the more compact areas of Elk City, contain also an abundance of pegmatitic, granitic, and dioritic dikes. The gneiss is sometimes injected by a great number of narrow pegmatite dikelets which have suffered a crumpling at the same time as the surrounding foliated rocks.

GNEISS.[b]

In a prevailing terrane of intrusive granite the Bitterroot and the Clearwater mountains contain numerous areas of gneissoid rocks of very differing ages. Some are later than the granite, of which they indeed, are only a modification, caused by peculiarly applied stresses. If the conclusion as to the age of the granite is correct, these gneisses are post-Triassic. Others are of much greater age, being probably older than the associated sediments, which are themselves older than the granite. In these sediments no fossils have been found, and their true horizon is thus doubtful. Very likely, however, parts or all of this second series of gneisses may be of pre-Cambrian age.

The first and most extensive gneiss area is that which follows the well-marked eastern slope of the Bitterroots, and which is clearly nothing but a sheet

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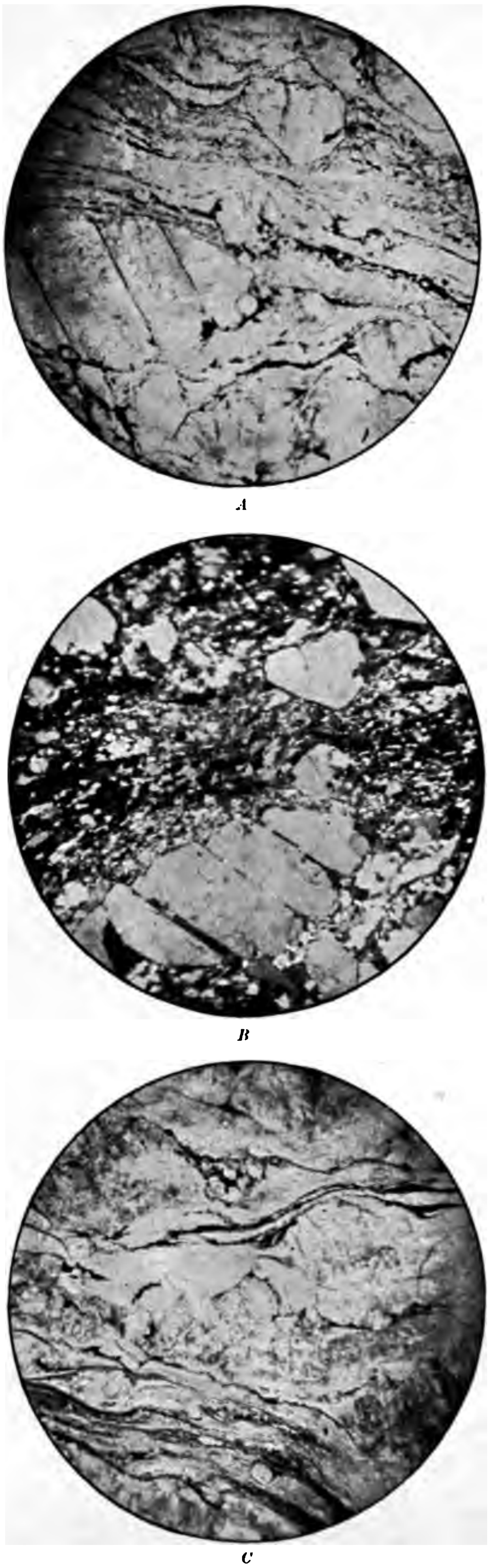
[a] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 79.

[b] The word gneiss is here used without limitations as to age and origin.



PHOTOMICROGRAPHS OF GNEISS OR GRANITE-SCHIST.

A, Gneiss or granite-schist from near mouth of Tin Cup Canyon; ordinary light, X 20.
B, Same as *A*; crossed nicols. X 20.
C, Gneiss or granite-schist from near mouth of Sawtooth Canyon. ordinary light, X 20

pseudophenocrysts the irregular, more frequently lenticular remains of larger grains. These are often cut by parallel cracks which dip about 70° E., and which are sometimes opened and filled by secondary quartz, suggesting a stretching movement.

Still further pressure results in dark, fine-grained bands in the coarser gneiss, which under the microscope appear to be suffused by extremely finely divided biotite with allotriomorphic feldspar and quartz. This mass contains small, rounded residua of larger grains, and the whole imitates fairly successfully a fine-grained clastic rock.

The second gneiss area is that of St. Marys Peak in the northern center of the range and probably underlying the sedimentary Lolo series. This dark-gray gneiss is very rich in black mica and weathers to reddish outcrops. It is usually crumpled and includes portions or streaks of exceedingly micaceous schists. The dip is usually steep toward the west. The origin of the rock is uncertain.

On the east side of the Bitterroot Valley the granite, which is presumably but not certainly of the same age as the normal Bitterroot granite, contains frequent, well-defined inclusions of a crumpled gneiss, like that of St. Marys Peak. It is believed that this gneiss is composed of fragments of a more extensive formation which had been shattered by the granite. In places the granite itself is somewhat schistose. Dip and strike of these roughly gneissoid rocks, as well as those of the inclusions, are characteristically variable.

The next big gneiss area is found at the very head of the South Fork of the Bitterroot, adjoining the quartzitic series of that valley, which probably is identical with that of the Lolo Fork; the contact, though difficult to interpret, probably indicates that the gneiss underlies the sedimentary formation. This gneiss, which is cut by many granite dikes, consists of medium-grained aggregates of quartz and feldspar with some larger deformed crystals of the same kind. The abundant aggregates of muscovite and biotite run in irregular bands, curving around the lenticular patches of quartz and feldspar. It is often contorted and sometimes of coarse grain. It contains much microcline and little plagioclase. The schistosity is variable, but most frequently it dips 40° E.

A similar gneiss area, perhaps connecting southward with the one just described, is found on Salmon Mountain; it is extensively broken and intruded by granite dikes. Both these areas are pretty surely dynamo-metamorphosed granitic rocks of much greater age than the Bitterroot granite.

A much larger gneiss area is that of Elk City. It is elliptical in form and extends 40 miles north and south and 24 miles east and west. It borders almost everywhere against granite, the contact plainly showing the intrusive nature of the latter rock. The gneiss of this area is uniform in character; it is which are intercalated in the [illegible] flows. Still higher up near the head of the river, on Jack Creek, a succession of flows of [illegible], [illegible], and [illegible] rhyolite is met with; the same flows form some point in the divide between the North and East forks.

While the general habit of these rocks unquestionably is that of rhyolites, the general prominence of phenocrysts of oligoclase suggests that they contain a large amount of soda. No analyses have been made. The age is probably Miocene or Pliocene.

Basalt.—From the last heights along the western margin of the Clearwater Mountains the vast plateau of the Columbia River basalt, covering thousands of square miles, spreads out in a magnificent view. The old Clearwater Plateau, rising to 7,000 feet above the sea, heavily forested, and deeply trenched by canyons, breaks off with rapid slope, and at its foot extends another plateau, much better defined, 4,000 feet lower, but still 3,000 feet above the sea. Its open fields lie in strong contrast to the dark-green Clearwater forests. The canyons are in reality much sharper incised than those of the older plateau, but seen from this point of view become indistinct. With a knowledge of the geological structure of the lava plateau, we can easily imagine how the molten rock in rapidly succeeding flows swept over and buried the foothills, perhaps at most permitting isolated high points to project above the lava, until at last these horizontal basaltic sheets had frequently attained a thickness of 2,000 feet and in a few places even of 4,000 feet. The enormous volume of congealed magma along the foot of the mountains dammed the old canyons of the rivers and forced the streams in their lower courses to seek new channels. New drainage systems were laid out on the basalt plateau; and corrading rivers cleared the partly filled canyons of the damming lava and excavated new trenches in the basaltic fields.

The basalt is a normal rock of its kind, usually an olivine-basalt, with a tendency to diabasic granular structure, glass remaining between the grains. Each of the many individual flows is ordinarily scoriaceous on top and more massive in the center. In a few places waterlaid clays and sands, with local lignites, are intercalated, doubtless accumulated by the rivers during lulls in the eruptions. Beds of tuff are absent.

The age of this basalt is generally conceded to be Miocene. The evidence, consisting mostly of fossil plants in interbedded sediments, has been gathered from various points and examined, chiefly by Professors Knowlton and Merriam.[a] No new evidence as to the age of this basalt has been obtained during this reconnaissance.

The original surface of the basalt was no doubt approximately level over large areas; still we are not justified in applying hydrostatic laws to the fluid rock, and it is very likely that if a focus of eruption was located high up on a mountain side the flows might have an initial dip of several degrees down to the level at which the main valleys were flooded. No positive evidence as to the manner of eruption has been obtained. As a negative bit of evidence it may be stated that no basalt dikes of any kind have been found along the western margin of the Clearwater Mountains. The only focus thus far discovered along the eastern shore of the basalt plain is that described in a previous publication[a] and located at elevations of up to 8,000 feet on the eastern slope of the Eagle Creek Range, in Oregon. As has been surmised from the great fluidity of the lavas, the magma seems to have been emitted from a great number of short dike fissures in quiet and continuous streams.

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[a] Knowlton, F. H., Bull. U. S. Geol. Survey No. 108, 1893, pp. 103-104.

Orographic dislocations have caused two folds in the level surface of the lava plateau. Most important among these is, first, the synclinal depression centering in Lewiston and bordered on the north by the monoclinal fold of the Clearwater escarpment; and second, the gentle anticline of the Craig Mountains, separating the Lewiston Plateau from Camas Prairie.

Slow earth movements on a grand scale are also believed to have affected the lava plateau. The principal movement seems to be a universal depression, perhaps induced by the extrusion of vast basalt masses from the interior. From a study of the courses and canyons of the antecedent rivers, like the Snake and the Salmon, it is surmised that certain marginal portions of the plateau may have been raised above the original level and that the extraordinarily deep canyons have resulted from an erosive trenching progressing simultaneously with this uplift.

QUATERNARY FORMATIONS.

The distinctly Quaternary deposits of this region are principally those connected with glaciation. Heavy moraines lie at the foot of the southern part of the Bitterroot Range, and glacial accumulations are found in all the valleys descending eastward and westward from their crests. From the Nez Perce to the Lolo Pass this range was covered by a sheet of névé and ice. Smaller moraines indicating a local glaciation are found on Salmon Mountain, The Crags, Buffalo Hump, Grave Peak, Rhodes Peak, and the Rocky Ridge, but over a larger part of the Clearwater Mountains below an elevation of 7,000 feet, as well as along Lolo Fork and the South Fork of the Bitterroot River there is no indication of glaciation. It is also believed that the larger part of the Coeur d'Alene Mountains was free from ice during the Glacial epoch. South of Mullan Pass and generally near the highest points there is some evidence of local glacial basins. In this more northerly region the limit of glaciation seems to lie a little lower than in the Clearwater Mountains.

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[a] Lindgren, W., Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 740-742.

Deep gravels accumulated in the valley of the Bitterroot River and its branch streams during the Glacial epoch and, since its close, have been gradually excavated and terraced. The bottom lands along the rivers and the dried-lake basins in the glaciated district are the most recent Quaternary deposits.

GEOLOGICAL HISTORY.

An exact statement of the geological history of this region is difficult to give on account of the few exactly determinable datum planes. There are really only two determinations of time on which we may rely. The first is the date of the Columbia River lava as Miocene; the second is the Glacial epoch as early Quaternary. Back of the Columbia River lava the ages given for the sedimentations, intrusions, and dislocations are only tentative.

The oldest rocks known are probably the gneisses of the Clearwater Mountains; more recent than these are the sediments of supposed pre-Cambrian, Carboniferous, and Triassic age. We may conceive a post-Triassic uplift of great importance, followed or accompanied by vast intrusions of granite, the granite of the Bitterroot, Clearwater, Salmon, and Coeur d'Alene mountains.

We may further, with great probability, assume a long-continued erosion, which planed down this uplift to the moderate relief of the Clearwater, Salmon, and Coeur d'Alene plateaus, and which exposed the intrusive granite by the removal of great masses of covering sediments.

Going one step further, it is necessary to assume a second great and evenly-distributed uplift which raised this eroded surface several thousand feet above the sea, an uplift of post-Triassic and pre-Miocene age. This was probably accompanied by breaks along what is now the western margin of the plateau, and was necessarily followed by the establishment of the systems of the Bitterroot, Clearwater, and the Salmon rivers. These streams trenched the plateau broadly and deeply, with the result that their canyons during the Miocene epoch were cut to a depth equal to that of the present day. The relations of the Columbia River lava to the old topography prove this on the western side, and similar evidence is adduced for the South Fork of the Bitterroot, by the fact that the rhyolites there filled a valley coinciding in depth and configuration with that of to-day.

Going back a little further from the Miocene datum plane, perhaps to a time when the Bitterroot River first flowed over the uplifted plateau, which probably reached far into Montana, a dislocation of great importance occurred along what is now the Bitterroot Range. This dislocation, the beginning of which perhaps scarcely antedated the close of the Cretaceous period, extended for 60 miles north and south, only bending westward close to its southern end. This fault plane was inclined eastward at angles up to 26° from the horizontal, and the rocks along it bear evidence both of molecular and molar movement;

the former expressed in schistosity, the latter in striated slipping planes. The direction of the movement was that of a normal fault, and seemed to have been of a stretching and shearing character. The foot wall seems to have moved up as expressed by the raising of the Bitterroot Range above the general level of the Clearwater Plateau. The hanging wall seems to have moved down as expressed by the apparently structural trough of the Bitterroot Valley. The minimum amount of the dislocation along the plane of fault is 2 or 3 miles; the minimum horizontal component would be but little less, while the corresponding vertical component is about 5,000 feet. The evidence finally shows that movement along this dislocation has proceeded for a very long time, and probably still continues along certain parts of the fault. The flat dip of the fault plane has naturally aided the preservation of the record.

During the latter part of the Miocene epoch, important events happened. The western foot of the Clearwater Mountains was flooded by basalt, poured out through fissures in enormous volume. The foothills were covered by rapidly succeeding outbursts of very fluid lava, piled up in a great number of thin flows, which had a maximum thickness of 4,000 feet, and finally reached a level of about 3,000 feet above the sea, as the land stands to-day. The lower river courses were entirely changed; while the canyons of the Clearwater Mountains, though dammed by basalt, still preserved their form and direction.

The last part of Tertiary time, and perhaps the beginning of the Pleistocene, was occupied by the rivers on the western slope in undoing the constructive work of the earlier eruptions. Steep and sharply incised canyons were eroded along new stream courses along the lower Clearwater and the Salmon rivers, while the trunk stream of the Snake River cut out an entirely new course from Wieser (at the lower end of the Great Snake River Valley) to its mouth. The canyons were cleared of accumulations, and at the beginning of the Glacial epoch the rivers of the western slope had trenched their canyons very nearly to the depth they have to-day. The filling of the canyons by lava had probably, in most cases, produced accumulation of gravel terraces along the upper parts of the watersheds, and of such character are probably the auriferous terrace gravels of Elk City, on the South Fork of the Clearwater, the highest level of which reaches 4,500 feet in elevation. In the lower stream courses the pre-Miocene drainage channels now lie below the bottom of the present streams; from this it seems probable that a large part of the field of the Columbia River lava has undergone a subsidence since the time of the eruptions; a subsidence probably caused by the eruption of large masses of magma from the interior of the earth. Minor folds have occurred in the once horizontal lava beds, as near Lewiston. Finally, the courses of the Snake River and the lower part of Salmon River seem to indicate that an uplift has occurred along certain marginal parts of the lava direction. In the upper 15 miles its width is only from 2 to 4 miles. Westward the Bitterroot Range rises with its remarkably even slope and deeply incised canyons, while eastward, with gentler slope and far less pronounced outlines, are the foothills which gradually lead up to the main divide of the Rocky Mountains toward Phillipsburg. The Bitterroot River pursues its course in a northerly direction with an average grade of 20 feet per mile, receiving many tributaries from the western mountains and a few from the much more arid eastern foothills. Those from the west, which generally have an east-west direction within the range, are usually sharply deflected northeasterly, where they debouch into the valley.

CULTURE AND VEGETATION.

Owing to a moderate elevation of from 3,900 to 3,150 feet, good soils, and excellent water supply, the Bitterroot Valley forms one of the most prosperous agricultural areas of Montana. There are many little towns, the largest among which is Hamilton, picturesquely situated in the middle of the valley, with beautiful view across to the serrated and snowy ridges of the Bitterroot. The hardier fruits thrive, as well as cereals and forage plants, but irrigation is everywhere necessary. Along the river is a moderate growth of deciduous trees and a few pines; the gravel terraces and the eastern foothills are partly open; while the lower hills of the Bitterroot Range are covered by thick timber. The forests and soils of this region have been described in much detail by Mr. J. B. Leiberg.[a]

GEOLOGY.

QUATERNARY.

A large amount of Quaternary deposits lie in the deep trough of the Bitterroot Valley, and there is evidence that it was once filled to a much higher level than at present. The greater part of this material is doubtless derived from the moraines and glacial streams which came down from the valleys of the western range, but much of it has also been brought down from the canyons of the upper river.

At the forks of the river, 25 miles south of Hamilton, the alluvial bottom lands are about 1 mile wide and continue with the same width downstream toward Grantsdale. From this point northward to the end of the valley the bottom lands are ordinarily several miles wide. These latest alluvial deposits are throughout the valley flanked by gravelly terraces, often several miles wide. Near the forks of the river and upstream toward Darby there are at least two prominent terraces on the west side at elevations of 100 and 200 feet above the river. In some places these are sharply defined and at others merge into the slopes of the valley. The highest is at an elevation of about 4,100 feet. Near the river

the belief that the two last-named areas on the east side are very old, possibly pre-Cambrian, while the western area probably includes Triassic, Carboniferous, and possibly still older sediments.

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[a] Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 5, 1899, pp. 253-282.

The sedimentary series of the Lolo Fork, in the northeast corner of the area, consists of moderately metamorphosed quartzites, limestone, and banded slates, some of them of a purple color. This apparently conformable but evidently folded, overturned, and repeated series has a northwesterly or west-northwesterly strike and a prevailing northeasterly dip of 30° to 45°, and borders south and west against later granite with intrusive contact. The chief interest of this series lies in the fact that it is probably the southward end of the similar very extensive area which in the Coeur d'Alene section, 75 miles farther north, occupies the whole width of the Coeur d'Alene Mountains from the lake of the same name up to Mullan Pass, and thence down to the Clark Fork of the Columbia by way of St. Regis de Borgia River. Throughout, this Coeur d'Alene series has a west-northwest or northwesterly strike and usually a moderate northeasterly dip. No fossils have been found in it, and my belief is that it should be coordinated with the thick pre-Cambrian series of central Montana.

Small exposures of the same or a similar series are noted along the foothills of the Bitterroot Valley and again on the Skalkaho and Weeping Child Creek, where they also border intrusive granite.

A series of quartzites or quartzitic schists and slates occupies a considerable area at the very head of the South Fork of the Bitterroot and extends at least as far as Gibbonsville, Idaho, on the east. They appear to be thrown into flat folds dipping east or west at moderate angles. They are probably intruded by granite and certainly by granite-porphyry on the north, and border against older gneisses on the south.

At the western foot of the Clearwater Mountains the most prominent sedimentary terrane is composed of black slates, limestones, quartzitic slates, and associated partly schistose and probably effusive greenstones which are found on the South Fork of the Clearwater and which extend only a short distance north of Harpsters. This series has a persistent northeasterly strike and steep dip, and evidently forms the northern continuation of beds of the same strike exposed at intervals below the Columbia River basalt on the lower Salmon, in the Seven Devils, and, over 100 miles distant, near Huntington. Triassic fossils have been found in the Seven Devils,[a] and a large part of this long area of sediments is believed to be of Triassic age. Still farther west sedimentary rocks of unknown age, but probably Paleozoic or Mesozoic, are exposed near the junction of the Salmon and Snake rivers, in the Cottonwood Buttes, and in Clearwater Canyon

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[a] Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 581.

composition; quartz is abundant in medium-size grains, while the feldspars are represented by both orthoclase and oligoclase, the latter usually in large quantity. Perthite is also frequently encountered, and more rarely microcline. The rock contains far too much oligoclase to be classed as a normal granite and should be rather characterized as a quartz-monzonite. Modifications more closely allied to granodiorite, diorite, and granite occur in subordinate quantity.

The granite is typically developed near the head of Mill Creek, Bitterroot Range, where it is a light-gray, medium-grained rock, with small foils of biotite and a little muscovite. A few larger crystals of orthoclase reach one-half inch in length. Under the microscope the rock shows much quartz, a little normal orthoclase, and many large grains of microperthite. An acidic oligoclase with very narrow striations is very abundant. Biotite and muscovite occur in scattered straight foils. Few accessories except zircon and apatite were noted, though titanite occurs abundantly in basic concretions in the same granite. The structure is typically granitic; the oligoclase is in part idiomorphic and sometimes included in the perthite. An analysis of this rock is given in the table below, together with such analyses of rocks as are available from the southern end of this great granitic batholith.

Analyses of granitic rocks from Idaho.

	I.	II.	III.	IV.	V.
SiO_2	72.07	69.56	68.42	65.23	57.78
Al_2O_3	15.51	15.29	15.01	16.94	16.28
Fe_2O_3	.31	.86	.97	1.60	1.02
FeO	1.01	2.06	1.93	1.91	4.92
MgO	.35	.69	1.21	1.31	4.60
CaO	1.93	2.81	2.60	3.85	6.65
Na_2O	4.02	3.97	3.22	3.57	3.25
K_2O	4.09	3.36	4.25	3.02	2.22
H_2O below 110° C	.03	[a].86	.54	.18	.34
H_2O above 110° C	.30		.73	.88	.92
TiO_2	.16	.55	.50	.66	1.07
CO_2	None.	....	.20	.25	.15
P_2O_5	.11	.16	.13	.19	.30
S	....	....	.02	....	.02
NiO and CoO	....	....	None.	....	.02
MnO	Trace.	....	.06	Trace.	.15
BaO	....	....	.12	.19	.12
SrO	....	....	.03	....	.07
Li_2O	....	....	Trace.	....	Trace.
	99.89	100.17	99.94	99.78	99.88

[a] Loss on ignition.

I. Quartz-monzonite. Near head of Mill Creek, Bitterroot Range, Montana. W. F. Hillebrand, analyst.

II. Quartz-monzonite, No. 46, Boise collection. Shafer Butte, Boise County, Idaho. George Steiger, analyst. Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 82.

III. Quartz-monzonite, No. 25, Hailey collection. Democrat mine, near Hailey, Blaine County, Idaho. W. F. Hillebrand, analyst. Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 82.

IV. Granodiorite, No. 79, Boise collection. Silver Wreath tunnel, Willow Creek mining district, Boise County, Idaho. George Steiger, analyst. Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 82.

V. Diorite, No. 32, Hailey collection. Crœsus mine, near Hailey, Blaine County, Idaho. W. F. Hillebrand, analyst. Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, p. 82.

The approximately calculated composition of the rocks is as follows:

Calculated composition of rocks from Idaho.

	I.	II.	III.	IV.	V.
Quartz	28.73	28.04	29.21	25.00	8.45
Orthoclase molecule	20.04	15.84	18.07	11.21	7.57
Albite molecule	33.98	33.54	27.19	30.25	26.20
Anorthite molecule	8.36	11.15	9.53	13.88	20.45
Biotite[a]	[b]8.03	7.55	12.36	15.99	[c]32.55
Apatite	.27	.37	.47	.44	.69
Titanite	.29	1.13	.88	1.65	1.29
Magnetite	.17	.93	.31	.61	1.48
Calcite			.45	.57	.33
Pyrite			.03		.03
Hygroscopic water	.03	.36	.54	.18	.34
Excess combined water		.27	.32		.51
Total	99.90	99.18	99.36	99.78	99.89

[a] Molecular ratio assumed: MgO: SiO_2: TiO_2: Al_2O_3: Fe_2O_3: FeO: CaO: K_2O: H_2O=1: 2.44: .06: .75: .14: .88: .04: .42: .76.

[b] Biotite, 5.03; muscovite, 3.00. Molecular ratio of biotite in this analysis figures out to MgO: SiO_2: Al_2O_3: Fe_2O_3: FeO: CaO: K_2O: H_2O: TiO_2=1: 3.64: 1.11: .14: 1.52: .04: .42: 1.04: .06

[c] Biotite, diallage, hypersthene, hornblende.

The analysis of the rock from the Bitterroot Range shows so great similarity to II and III, both of which are representative rocks, that no special calculation seems necessary. It contains the same amount of quartz and a more sodic oligoclase, while the potash feldspar is slightly increased, a little muscovite being present in I. Analyses IV and V represent local basic modifications. The five analyses form a series with gradually lowered SiO_2, constant Al, and increasing Fe, Mg, Ca. The first three rocks should doubtless be considered as quartz-monzonites, though I distinctly approaches the granites.

In the Bitterroot Mountains streaks of basic magmatic segregations often appear, characterized by biotite and hornblende, quartz, orthoclase, oligoclase, and andesine, together with much titanite. Almost normal granites with prevailing orthoclase were observed west of Little Salmon Meadows and on the head of Crooked River. Dioritic modifications were observed near the schist contact at Pierce, and in the Clearwater Canyon near Greers Ferry. At the latter place a very fine diorite-pegmatite, consisting of hornblende and a plagioclase of medium acidity, is exposed in a railroad cut near the river.

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GNEISS.[b]

In a prevailing terrane of intrusive granite the Bitterroot and the Clearwater mountains contain numerous areas of gneissoid rocks of very differing ages. Some are later than the granite, of which they indeed, are only a modification, caused by peculiarly applied stresses. If the conclusion as to the age of the granite is correct, these gneisses are post-Triassic. Others are of much greater age, being probably older than the associated sediments, which are themselves older than the granite. In these sediments no fossils have been found, and their true horizon is thus doubtful. Very likely, however, parts or all of this second series of gneisses may be of pre-Cambrian age.

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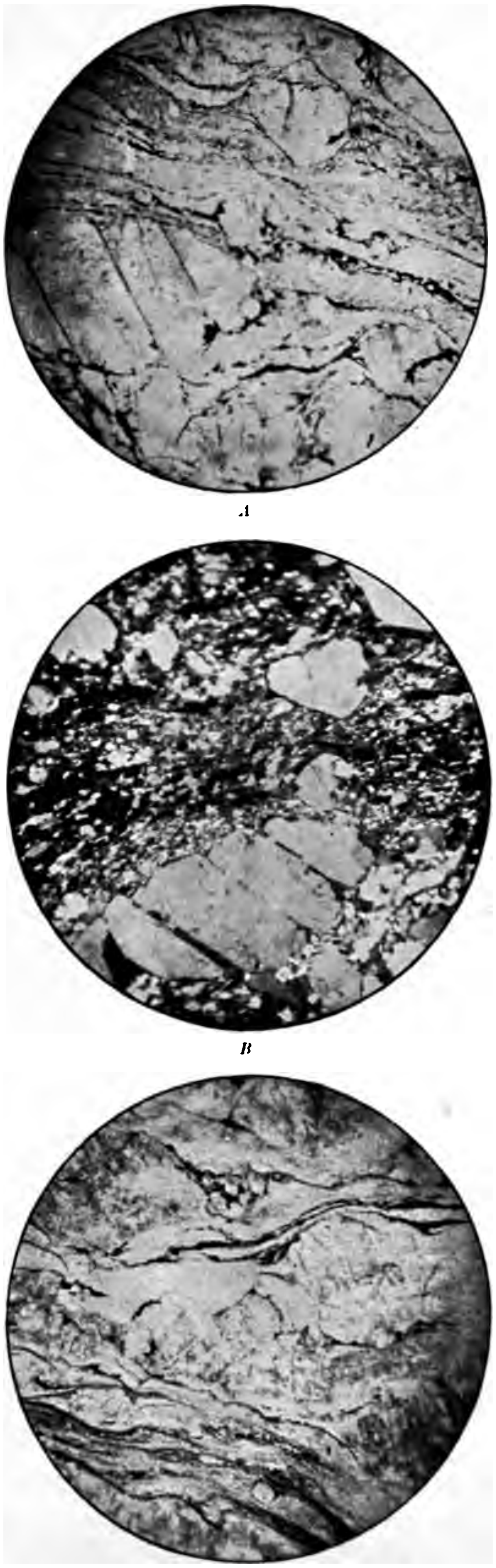

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A, Gneiss or granite-schist from near mouth of Tin Cup Canyon; ordinary light, X 20.
B, Same as *A*; crossed nicols, X 20.
C, Gneiss or granite-schist from near mouth of Sawtooth Canyon; ordinary light, X 20

of pressed and deformed granite. It is usually a light-gray, granular, and schistose rock, and consists of lenticular squeezed aggregates of oligoclase and quartz and deformed orthoclase crystals, separated by somewhat curved aggregates of new-formed biotite and muscovite. The primary constituents are the same as those of the granite. All transitions toward massive granite may be seen. Excessive compression results in finer-grained and darker micaceous schists. This gneiss is characterized by abundant slipping planes, which show movements parallel to the dip, and on which large plates of muscovite have often formed. As far as the observations showed, this gneiss is never crumpled and folded like the older gneisses.

The incipient gneissoid structure may be well observed in the gneissoid granite of Lost Horse Pass near Twin Lakes. (Pl. V.) Macroscopically it is light-gray granular rock of medium grain. The schistose structure is not prominent, but indicated by the distribution of the biotite and the lenticular shape of larger feldspar crystals. Under the microscope the large grains consist of quartz, orthoclase, and oligoclase, very similar to those in the normal granite. The biotite is largely recrystallized and converted to stringy aggregates of the same mineral partly changed into chlorite. Some muscovite is also present. There is an abundant development of new allotriomorphic fine-grained aggregates along winding and curving shearing planes. This aggregate consists of feldspar, mostly without striations, and quartz; there is also much micropegmatite, and in places a coarse poikilitic structure. Black iron ore in irregular, sometimes pressed, grains as well as apatite and zircon are accessories.

About halfway up Lost Horse Creek similar but more schistose rocks were observed. Their appearance under the microscope is similar to the specimens just described; in addition the larger grains are greatly crushed with much cataclastic structure. The normal gneiss from Mill Creek, 2 miles above the mouth of the canyon, is a plainly schistose rock with large orthoclase crystals pressed into partly lenticular shape. Biotite and a little muscovite lie in flat aggregates between streaks of pressed feldspar and quartz. There is much cataclastic action and formation of new allotriomorphic aggregates along wavy lines, which indicate schistosity. Large feldspar and quartz grains, when crossed by these lines, are greatly crushed. On the whole, however, the rock has great similarity to the normal Bitterroot granite.

Stronger crushing action near the mouth of the canyons simply results in emphasizing the characteristics already referred to. The sinuous lines along which most active recrystallizing movement is in progress multiply, and at last the whole rock is transformed into a fine-grained aggregate traversed by wavy streaks of finely distributed biotite and a little muscovite, and in this mass lie as seams are intercalated in the felsitic flows. Still higher up near the head of the river, on Lick Creek, a succession of flows of glassy, felsitic, and tuffaceous rhyolite is met with; this came down from some point on the divide between the South and East forks.

While the general habit of these rocks unquestionably is that of rhyolites, the general prevalence of phenocrysts of oligoclase suggests that they contain a a large amount of soda. No analyses have been made. The age is probably Miocene or Pliocene.

Basalt.—From the last heights along the western margin of the Clearwater Mountains the vast plateau of the Columbia River basalt, covering thousands of square miles, spreads out in a magnificent view. The old Clearwater Plateau, rising to 7,000 feet above the sea, heavily forested, and deeply trenched by canyons, breaks off with rapid slope, and at its foot extends another plateau, much better defined, 4,000 feet lower, but still 3,000 feet above the sea, its open fields in strong contrast to the dark-green Clearwater forests. The canyons are in reality much sharper incised than those of the older plateau, but seen from this point of view become indistinct. With a knowledge of the geological structure of the lava plateau, we can easily imagine how the molten rock in rapidly succeeding flows swept over and buried the foothills, perhaps at most permitting isolated high points to project above the lava, until at last these horizontal basaltic sheets had frequently attained a thickness of 2,000 feet and in a few places even of 4,000 feet. The enormous volume of congealed magma along the foot of the mountains dammed the old canyons of the rivers and forced the streams in their lower courses to seek new channels. New drainage systems were laid out on the basalt plateau; and corrading rivers cleared the partly filled canyons of the damming lava and excavated new trenches in the basaltic fields.

The basalt is a normal rock of its kind, usually an olivine-basalt, with a tendency to diabasic granular structure, glass remaining between the grains. Each of the many individual flows is ordinarily scoriaceous on top and more massive in the center. In a few places waterlaid clays and sands, with local lignites, are intercalated, doubtless accumulated by the rivers during lulls in the eruptions. Beds of tuff are absent.

The age of this basalt is generally conceded to be Miocene. The evidence, consisting mostly of fossil plants in interbedded sediments, has been gathered from various points and examined, chiefly by Professors Knowlton and Merriam.[a] No new evidence as to the age of this basalt has been obtained during this reconnaissance.

The original surface of the basalt was no doubt approximately level over large areas; still we are not justified in applying hydrostatic laws to the fluid rock, and it is very likely that if a focus of eruption was located high up on a mountain side the flows might have an initial dip of several degrees down to the level at which the main valleys were flooded. No positive evidence as to the manner of eruption has been obtained. As a negative bit of evidence it may be stated that no basalt dikes of any kind have been found along the western margin of the Clearwater Mountains. The only focus thus far discovered along the eastern shore of the basalt plain is that described in a previous publication[a] and located at elevations of up to 8,000 feet on the eastern slope of the Eagle Creek Range, in Oregon. As has been surmised from the great fluidity of the lavas, the magma seems to have been emitted from a great number of short dike fissures in quiet and continuous streams.

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[a] Knowlton, F. H., Bull. U. S. Geol. Survey No. 108, 1893, pp. 103–104.

Orographic dislocations have caused two folds in the level surface of the lava plateau. Most important among these is, first, the synclinal depression centering in Lewiston and bordered on the north by the monoclinal fold of the Clearwater escarpment; and second, the gentle anticline of the Craig Mountains, separating the Lewiston Plateau from Camas Prairie.

Slow earth movements on a grand scale are also believed to have affected the lava plateau. The principal movement seems to be a universal depression, perhaps induced by the extrusion of vast basalt masses from the interior. From a study of the courses and canyons of the antecedent rivers, like the Snake and the Salmon, it is surmised that certain marginal portions of the plateau may have been raised above the original level and that the extraordinarily deep canyons have resulted from an erosive trenching progressing simultaneously with this uplift.

QUATERNARY FORMATIONS.

The distinctly Quaternary deposits of this region are principally those connected with glaciation. Heavy moraines lie at the foot of the southern part of the Bitterroot Range, and glacial accumulations are found in all the valleys descending eastward and westward from their crests. From the Nez Perce to the Lolo Pass this range was covered by a sheet of névé and ice. Smaller moraines indicating a local glaciation are found on Salmon Mountain, The Crags, Buffalo Hump, Grave Peak, Rhodes Peak, and the Rocky Ridge, but over a larger part of the Clearwater Mountains below an elevation of 7,000 feet, as well as along Lolo Fork and the South Fork of the Bitterroot River there is no indication of glaciation. It is also believed that the larger part of the Coeur d'Alene Mountains was free from ice during the Glacial epoch. South of Mullan Pass and generally near the highest points there is some evidence of local glacial basins. In this more northerly region the limit of glaciation seems to lie a little lower than in the Clearwater Mountains.

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[a] Lindgren, W., Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 740-742.

Deep gravels accumulated in the valley of the Bitterroot River and its branch streams during the Glacial epoch and, since its close, have been gradually excavated and terraced. The bottom lands along the rivers and the dried-lake basins in the glaciated district are the most recent Quaternary deposits.

GEOLOGICAL HISTORY.

An exact statement of the geological history of this region is difficult to give on account of the few exactly determinable datum planes. There are really only two determinations of time on which we may rely. The first is the date of the Columbia River lava as Miocene; the second is the Glacial epoch as early Quaternary. Back of the Columbia River lava the ages given for the sedimentations, intrusions, and dislocations are only tentative.

The oldest rocks known are probably the gneisses of the Clearwater Mountains; more recent than these are the sediments of supposed pre-Cambrian, Carboniferous, and Triassic age. We may conceive a post-Triassic uplift of great importance, followed or accompanied by vast intrusions of granite, the granite of the Bitterroot, Clearwater, Salmon, and Coeur d'Alene mountains.

We may further, with great probability, assume a long-continued erosion, which planed down this uplift to the moderate relief of the Clearwater, Salmon, and Coeur d'Alene plateaus, and which exposed the intrusive granite by the removal of great masses of covering sediments.

Going one step further, it is necessary to assume a second great and evenly-distributed uplift which raised this eroded surface several thousand feet above the sea, an uplift of post-Triassic and pre-Miocene age. This was probably accompanied by breaks along what is now the western margin of the plateau, and was necessarily followed by the establishment of the systems of the Bitterroot, Clearwater, and the Salmon rivers. These streams trenched the plateau broadly and deeply, with the result that their canyons during the Miocene epoch were cut to a depth equal to that of the present day. The relations of the Columbia River lava to the old topography prove this on the western side, and similar evidence is adduced for the South Fork of the Bitterroot, by the fact that the rhyolites there filled a valley coinciding in depth and configuration with that of to-day.

Going back a little further from the Miocene datum plane, perhaps to a time when the Bitterroot River first flowed over the uplifted plateau, which probably reached far into Montana, a dislocation of great importance occurred along what is now the Bitterroot Range. This dislocation, the beginning of which perhaps scarcely antedated the close of the Cretaceous period, extended for 60 miles north and south, only bending westward close to its southern end. This fault plane was inclined eastward at angles up to 26° from the horizontal, and the rocks along it bear evidence both of molecular and molar movement;

the former expressed in schistosity, the latter in striated slipping planes. The direction of the movement was that of a normal fault, and seemed to have been of a stretching and shearing character. The foot wall seems to have moved up as expressed by the raising of the Bitterroot Range above the general level of the Clearwater Plateau. The hanging wall seems to have moved down as expressed by the apparently structural trough of the Bitterroot Valley. The minimum amount of the dislocation along the plane of fault is 2 or 3 miles; the minimum horizontal component would be but little less, while the corresponding vertical component is about 5,000 feet. The evidence finally shows that movement along this dislocation has proceeded for a very long time, and probably still continues along certain parts of the fault. The flat dip of the fault plane has naturally aided the preservation of the record.

During the latter part of the Miocene epoch, important events happened. The western foot of the Clearwater Mountains was flooded by basalt, poured out through fissures in enormous volume. The foothills were covered by rapidly succeeding outbursts of very fluid lava, piled up in a great number of thin flows, which had a maximum thickness of 4,000 feet, and finally reached a level of about 3,000 feet above the sea, as the land stands to-day. The lower river courses were entirely changed; while the canyons of the Clearwater Mountains, though dammed by basalt, still preserved their form and direction.

The last part of Tertiary time, and perhaps the beginning of the Pleistocene, was occupied by the rivers on the western slope in undoing the constructive work of the earlier eruptions. Steep and sharply incised canyons were eroded along new stream courses along the lower Clearwater and the Salmon rivers, while the trunk stream of the Snake River cut out an entirely new course from Wieser (at the lower end of the Great Snake River Valley) to its mouth. The canyons were cleared of accumulations, and at the beginning of the Glacial epoch the rivers of the western slope had trenched their canyons very nearly to the depth they have to-day. The filling of the canyons by lava had probably, in most cases, produced accumulation of gravel terraces along the upper parts of the watersheds, and of such character are probably the auriferous terrace gravels of Elk City, on the South Fork of the Clearwater, the highest level of which reaches 4,500 feet in elevation. In the lower stream courses the pre-Miocene drainage channels now lie below the bottom of the present streams; from this it seems probable that a large part of the field of the Columbia River lava has undergone a subsidence since the time of the eruptions; a subsidence probably caused by the eruption of large masses of magma from the interior of the earth. Minor folds have occurred in the once horizontal lava beds, as near Lewiston. Finally, the courses of the Snake River and the lower part of Salmon River seem to indicate that an uplift has occurred along certain marginal parts of the lava plateau; the deepening of the canyon keeping step with the rate of the uplift. Only on such a supposition can we account for the abnormally deep canyons, which sometimes are cut 5,000 feet below the plateau surface.

On the eastern slope the happenings of late Tertiary time are less easily traceable, but it is probable that the damming by basalt of the Clark Fork of the Columbia and the subsidence of Bitterroot Valley along the great fault made a lake basin of this valley for a limited time..

One of the last events in the geological history is the glaciation which during the later part of the Quaternary period covered the whole Bitterroot Range with ice and snow and produced the extremely rugged forms which now characterize its surface region. Glaciers extended to the mouth of the eastern canyons of the range and also far down into the Clearwater drainage. Great moraines were accumulated at the southern end of the Bitterroot Mountains. The Clearwater Mountains were not uniformly glaciated, but contained numerous small glacial centers, such as The Crags, Grave Peak, Rocky Ridge, Salmon Mountain, and the Buffalo Hump region. From causes not clearly recognized as yet, the Lolo Fork, the main valley, and the South Fork of the Bitterroot River were during the Glacial epoch filled with gravels to a height of 400 or 500 feet above the present level of the stream. Similarly, we find evidence of a damming of the Snake and the Salmon canyons, with accompanying accumulation of sands and gravels to a depth of about 300 feet. Less evidence of this kind is available from the Clearwater system, though this also must have been similarly filled.

Finally these accumulations were removed, and during this clearing out the terraces and bottom lands which now line the Bitterroot Valley were formed; gravel bars were left in places along the lower Clearwater, the Salmon, and the Snake; morainal material was worked over and terminal moraines trenched; basins of glacial lakes were filled and converted into meadows.

Beyond this there has been only a slight deepening of the canyons of the great rivers. In glacial regions the marks of the ice seem as if dating from yesterday. Except in the region of the Columbia River lava, the rivers have deepened their channels but little since early Tertiary time. The influences causing this retardation are the Miocene lava dams, the post-Miocene subsidence, and the obstructions to the rivers during the Glacial epoch.

BITTERROOT VALLEY.

TOPOGRAPHY.

Bitterroot Valley extends, properly speaking, from the point where the Lolo Fork enters the Bitterroot River to a point 5 miles south of Darby, where the river splits into two main branches. It is a well-marked depression about 65 miles long and up to 9 miles wide in its broadest portion, with a nearly north-south direction. In the upper 15 miles its width is only from 2 to 4 miles. Westward the Bitterroot Range rises with its remarkably even slope and deeply incised canyons, while eastward, with gentler slope and far less pronounced outlines, are the foothills which gradually lead up to the main divide of the Rocky Mountains toward Phillipsburg. The Bitterroot River pursues its course in a northerly direction with an average grade of 20 feet per mile, receiving many tributaries from the western mountains and a few from the much more arid eastern foothills. Those from the west, which generally have an east-west direction within the range, are usually sharply deflected northeasterly, where they debouch into the valley.

CULTURE AND VEGETATION.

Owing to a moderate elevation of from 3,900 to 3,150 feet, good soils, and excellent water supply, the Bitterroot Valley forms one of the most prosperous agricultural areas of Montana. There are many little towns, the largest among which is Hamilton, picturesquely situated in the middle of the valley, with beautiful view across to the serrated and snowy ridges of the Bitterroot. The hardier fruits thrive, as well as cereals and forage plants, but irrigation is everywhere necessary. Along the river is a moderate growth of deciduous trees and a few pines; the gravel terraces and the eastern foothills are partly open; while the lower hills of the Bitterroot Range are covered by thick timber. The forests and soils of this region have been described in much detail by Mr. J. B. Leiberg.[a]

GEOLOGY.

QUATERNARY.

A large amount of Quaternary deposits lie in the deep trough of the Bitterroot Valley, and there is evidence that it was once filled to a much higher level than at present. The greater part of this material is doubtless derived from the moraines and glacial streams which came down from the valleys of the western range, but much of it has also been brought down from the canyons of the upper river.

At the forks of the river, 25 miles south of Hamilton, the alluvial bottom lands are about 1 mile wide and continue with the same width downstream toward Grantsdale. From this point northward to the end of the valley the bottom lands are ordinarily several miles wide. These latest alluvial deposits are throughout the valley flanked by gravelly terraces, often several miles wide. Near the forks of the river and upstream toward Darby there are at least two prominent terraces on the west side at elevations of 100 and 200 feet above the river. In some places these are sharply defined and at others merge into the slopes of the valley. The highest is at an elevation of about 4,100 feet. Near the river are lower gravel terraces, 8 and 30 feet above the water level. The upper terrace leans against gradually rising hills of heavy moraines. On the east side there are few terraces south of Grantsdale, for the river is closely crowded against the rocky foothills of that side. From Grantsdale north the terraces become wider. East of Roaring Lion Creek there is a 30-foot terrace on the west side of the river, with a gradual slope covered with heavy gravel wash, which extends to the first moraine at the mouth of the canyon, which is 400 feet above the river and at an elevation of 4,000 feet. Similar relations obtain at the mouth of Mill Creek, except that the gravel is finer and more sandy.

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[a] Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 5, 1899, pp. 253-282.

At various places between Curlew mine and the mouth of Bear Creek the gravel terrace contains much quartzite in large cobbles, the origin of which seems somewhat doubtful, as there is not much quartzite in place close by. At the Curlew mine the gradual gravel slope reaches up from the river to the foothills, 200 feet above. On a spur 500 feet above the mine and 700 feet above the river lies a patch of well-washed gravel, the elevation of which (4,033 feet) must indicate the height to which the valley was once filled. Immediately north of Big Creek the gravel again reaches up to an elevation of 4,000 feet.

Near Florence, in the northern part of the valley, the gravel terrace skirts the river, the banks being 20 feet high in places. From the Curlew mine north the gravel contains much coarse, micaceous gneiss and the sands are full of mica. The evidence, as far as it goes, indicates that during the Glacial epoch the Bitterroot Valley was filled with gravels and sands to an elevation of about 4,000 feet along the margins, and that the grade of the river was then less than at present.

No direct evidence of the former existence of a lake within the valley has been found. The east side, however, has not been carefully examined, and from the general configuration it would seem possible that this depression, like many other intermontane valleys of this region, was occupied by a lake in late Tertiary time.[a]

It seems highly improbable that the Bitterroot Valley, at least north of Grantsdale, has been formed by erosion alone. It bears too many characteristics of structural valleys, and it seems not out of the way to tentatively associate its origin with that of the great range to the west of it. This subject will be referred to again in the description of the mountains.

EASTERN FOOTHILLS.

TOPOGRAPHY.

As far south as Skalkaho Creek the foothills on the eastern side of Bitt root Valley are low, ascending gradually in many low spurs from gravel terra "The crest line lies about 30 miles east of the valley, but as a continuous r normal granitic rock; near the granite the quartzite contains bands of biotite-schists and is largely converted into banded hornfels with malacolite and biotite. Inclusions of these rocks are also contained in the granite. In places the granite dikes are pegmatites with much quartz. At the first contact in Weeping Child Creek the same phenomena are seen. Many of the granitic dikes here follow the bedding planes of the quartzite, while in the section described above they mainly break across them. The same contact metamorphic rocks are noted.

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[a] Mr. Bailey Willis states (orally) that he found soft, clayey beds, probably of lacustrine origin, on the nort Skalkaho Creek, in the first foothills, a few miles from Hamilton. These beds dip westward at an angle of 80°.

GRANITIC ROCKS.

The larger part of the foothills east of the river is occupied by granites and gneiss, the relations of which seem rather complicated. Much of the granite is a normal, massive, light-yellowish gray rock similar to that of the central Bitterroot Range and, like that, containing both biotite and muscovite. The grain is apt to vary and some specimens contain large orthoclase crystals. Such rocks are found on the lower Skalkaho and southeast of Darby. Larger and smaller fragments of gneissoid rock, rich in black mica and with contorted planes of schistosity, frequently occur as inclusions in this granite. Over large areas the granite itself has acquired a roughly schistose structure. This is seen on lower Weeping Child Creek, where the schistosity has an east-west direction, and in the hills east of Darby, where it strikes from N. 15° W. to N. 50° E., the dip being either westerly or easterly from 45° to 60°.

The most probable interpretation of these facts is that an old pre-Cambrian series of quartzite and of still older true gneisses was intruded by granite similar in age and type to the Bitterroot granite. While large quartzite areas are left, the contorted inclusions are the only remnants of the gneisses. The granite has subsequently by irregularly acting forces acquired local rough schistosity in various directions. The included gneiss fragments can not reasonably be interpreted as contact metamorphic parts of the quartzite series. The roughly gneissoid granites are very different from the strongly compressed gneisses of the Bitterroot Range and probably did not result from the same kind of stresses which were active at that place.

DIKES.

The granitic rocks contain abundant dikes of granite-porphyry, dark diorite-porphyry, and rhyolite.

RHYOLITE.

For a few miles south of Como post-office the east side of the river up to a height of 1,000 feet is lined by precipitous bluffs which are formed by a series of rhyolite flows dipping about 45° to 60° SE. A thickness of several hundred feet is exposed and the succession from the base up is as follows, the flows resting on gneissoid rock:

Section near Como post-office.

(1) Columnar rhyolitic tuff, weathering soft.
(2) White rhyolitic tuff, weathering soft.
(3) Red felsophyre, weathering brown.
(4) Soft white rhyolite.
(5) Massive white rhyolite.
(6) White breccia, with dark bands.
(7) Red felsophyre, with green and black bands of vitrophyre. Rhyolite is also found in a few places on the west side of the river covered by Quaternary terrace gravel.

LOLO FORK AND NORTH END OF BITTERROOT RANGE.

TOPOGRAPHY.

At Lolo post-office, 35 miles north of Hamilton and 10 miles south of Missoula, the foothills of the Bitterroot Valley advance close to the stream, and this point may be considered as the end of the valley, properly speaking. Near the same place is the northern termination of the Bitterroot Range. From Lolo Peak, about 9,000 feet in elevation, the slopes descend abruptly toward Lolo Fork, an important tributary of the Bitterroot River; north of Lolo Fork the complicated system of timbered ridges which mark the beginning of the Coeur d'Alene Mountains rarely attain 7,000 feet above the sea.

Along Lolo Fork for a few miles above its mouth the bottom lands have a maximum width of one-half mile, and are bordered on both sides by gradually rising hills. Soon, however, a canyon begins with flat though narrow bottom, and this is practically continuous to the head, the slopes rising steeply on both sides for a few hundred feet, continuing then along more gently inclined ridges. About 20 miles from the mouth an important tributary is received from the north, and near this place the valley widens and contains some meadow land at an elevation of 3,700 feet. A well-marked terrace is noted 500 feet above the valley, and from this the long ridges gradually ascend to elevations of 6,000 feet or more. An excellent view is afforded from them southeasterly toward the snow fields and serrated peaks of the Bitterroots, and northwesterly over the monotonous, heavily timbered ridges of the Coeur d'Alene Mountains, scarred by the tracks of extensive forest fires.

Above the North Fork the canyon continues for 10 miles to Hot Springs where the stream forks again, one branch extending 10 miles westward and heading near Rhodes Peak, while the other comes down with northerly direction from Lolo Pass, 8 miles distant.

Lolo Fork thus runs from west to east just north of the Bitterroot Range and may be considered to mark the boundary between this range and the southern part of what, in this report, has been called the Coeur d'Alene Mountains. Its length is about 40 miles, and its southern fork cuts in back of the main divide of the Bitterroot Range. A wagon road leads up to the Hot Springs (elevation 4,100 feet), a favorite summer resort with baths, and at this place the Lolo trail begins. In 1899 this part of the trail was in very bad condition, due to fallen timber between which the path runs in most eccentric curves. A gradually ascending ridge leads up to the divide which has an elevation of only about 5,200 feet. Lolo Pass is a broad, flat depression between the westerly spurs of the Bitterroots and the projecting ridges of Rhodes Peak in the Clearwater Mountains. Deep soil and extremely thick forest with underbrush cover the hills, between which extend a series of swampy meadows. A few miles westward the trail crosses the North Fork of the Lochsa Fork and views are obtained over the Clearwater Mountains, heavily forested, with deep though not precipitous canyons and with slightly undulating skyline. In many places white exposures of granite gleam in the openings of the forests.

GEOLOGY.

SEDIMENTARY SERIES.

For a distance of 20 miles in a straight line westward from its mouth Lolo Fork cuts across a sedimentary series with a general northwesterly strike and prevailing northeasterly dip. Near Hot Springs this series is cut off by intrusive granite, the contact line thence curving southward toward Lolo Pass. This same series occupies the extreme northern slopes of the Bitterroot Range and probably also Lolo Peak. Along the eastern front of the range it reaches down to the mouth of Carlton Canyon, 7 miles south of Lolo Fork, where it again is cut off by intrusive granite; thence the contact probably extends westward toward Lolo Pass. The micaceous, contorted gneiss of St. Marys possibly connects with the sedimentary area.

These sedimentary beds, which may be provisionally designated as the Lolo series, derive additional interest from their probable identity and continuity with the series occupying the entire width of the Coeur d'Alene Mountains, 90 miles northward, and extending from the lake of the same name on the west to Clark Fork of the Columbia on the east. In neither case has the age been established, no trace of fossils having thus far been found. That the beds are very old is evident; they may even be pre-Cambrian.

The study of the series began at the mouth of Lolo Fork close to the Lolo post-office. Cherty limestone and quartzite crop here with northwesterly strike, adjoined 1 mile farther up the fork by a narrow belt of purple shale or slate. Three miles above begins the mouth a broad belt of quartzite-schist with northwesterly strike and a dip of 83° NE. Going up Mormon Gulch, which empties into the fork near its mouth and heads near Lolo Peak, shales and cherty limestone are noted; these beds have a southwesterly dip of 55°; above them on the same gulch begins the same micaceous quartzite-schist which was observed on the main fork and which contains a few aplitic dikes.

In the main fork the quartzitic schists continue for several miles. The schist, which is clearly of sedimentary origin, splits easily in slabs coated with muscovite. Just below Westerman's ranch, 5 miles from the mouth of the river, a belt of thick-bedded quartzites crosses the canyon. The next part of the series continues for 2 miles and consists of calcareous quartzite with some shaly limestone, with same northwesterly strike and northeasterly dip. Half a mile above Woodmans Creek this is adjoined by heavy bedded quartzite, continuous for 1½ miles. The canyon now becomes narrower, and schists of a greenish color, probably largely altered eruptives, predominate. One mile below Spark's ranch a dike of quartz-diorite crosses the canyon; above this a white quartzitic schist is extensively developed, striking N. 44° to 74° W., and dipping 35° to 45° NE. A long ridge north of Spark's ranch was ascended to a point 2,000 feet above the valley and the series was here found to strike much more northerly, ranging from due N. to N. 15° W., and dipping about 20° W., implying some kind of a break between this part and the rocks exposed in the canyon. The beds are banded, calcareous rocks, greenstone-schists, and a large amount of purple slates, very similar to those near the mouth of Lolo Fork.

The white quartzitic schists continue with the same dip for several miles above Spark's, when they run over into cherty banded and streaked calcareous quartzites which do not appear very much altered. In spite of careful search no definite fossils were found. One dike of diorite-porphyry was observed on the north side of the river. The remaining distance of about 6 miles up to the granite contact near Hot Springs is occupied by banded and calcareous quartzites, interstratified with dark slates. While this series contains lime, it is not so distinctly calcareous as that exposed at the mouth of Woodmans Creek. The strike swings more to the west, being from N. 60° to 80° W. The dip is prevailingly from 15° to 45° NNE. In a straight line the distance from the mouth of the fork up to the contact is 20 miles, but except in the lower part the river does not cut squarely across the strike. No estimate of thickness of this series can be attempted on the basis of the foregoing observations, but it is apparent that it must be considerable, even allowing for folding, faulting, and repetition. There is a noticeable absence of pyritic impregnation, quartz veins, and dikes. While the series contains some sheared eruptives, there is certainly no great amount of this kind of rock.

LOLO CONTACT.

Just below Hot Springs, near the mouth of Granite Creek, is a sharp contact, though the actual contact plane is not well exposed and the drainage basin above this point is occupied by granite. The contact crosses Granite Creek near its mouth, and thence for many miles continues with a general direction of N. 80° W. To the south the contact changes its direction and appears to follow pretty close to Lolo Fork. Near Lolo Pass irregular areas of metamorphosed sediments were observed. The thick vegetation and deep soil give few opportunities for study of the rocks.

For several hundred feet from the contact the quartzitic slates are very crystalline, and minerals and structure typical of contact phenomena have developed in them. The exposures on the ridge east of the Hot Springs are not good, but at the contact the slates are very micaceous. The calcareous rocks have been altered to malacolite-hornfels, while the pure quartzite has obtained a dense flinty structure. A granite-porphyry with bipyramidal quartz crystals often appears on the immediate contact. The excellent outcrops, 1,200 feet below Hot Springs in the creek, show greenish crystalline schists, striking north-south and dipping 80° W. These schists contain many small dikes of muscovite-granite, aplite, and pegmatite, some containing tourmaline. A specimen 20 feet from the actual contact which is covered shows a biotite-andalusite hornfels with abundant tourmaline. The alteration decreases rapidly, though a specimen collected 1,000 feet below the contact, on Lolo Fork, appearing like a dark-gray, flinty quartzite, still shows the structure of hornfels and contains tourmaline. Half a mile below the contact banded slates appear with normal strike and dip, and very little altered, the chief evidence being little spots and knots on the cleavage faces. A few dikes of granite-porphyry were noted at this place.

The intrusive character of the granite into the Lolo sedimentary series is the main point established.

CARLTON CREEK CONTACT.

As might be expected, the quartzitic schists and quartzites of the lower Lolo Fork continue with northwesterly strike across the ridge between that river and the main Bitterroot Range, and are found along the foothills for 7 miles south of the junction. Quartzite is exposed to a point three-fourths of a mile north of the mouth of Carlton Creek Canyon, where knotty slates are interbedded and show strikes of N. 45° W., dip 45° NE. The slates are micaceous and contain in places abundant narrow dikes of pegmatitic and aplitic granite 5 to 6 inches wide, chiefly intruded parallel to the coinciding planes of schistosity and bedding. Going southward, more quartzite follows, and at Carlton Creek the contact of the sedimentary series with the granitic is reached. One of the interesting points of this contact is that the intrusive rock here consists of the normal gneiss of the Bitterroot front slopes, itself a dynamo-metamorphic development of granite. At this place the gneiss is imperfectly schistose, but the dip is from 15° to 18° E., as at most points farther south. About 2 miles above the mouth of the canyon this gneiss seems to gradually change into the normal granite abundantly exposed on the slopes facing north. The exact place of contact between gneiss or granite and quartzite is somewhat in doubt, so gradually increasing is the injection of the latter by pegmatite and granitic rocks. That this contact, too, is intrusive admits of no doubt, and it is accompanied by a more intense contact metamorphism than at Hot Springs on Lolo Fork, probably, because the series is here fractured across the bedding planes. In some places the interstratified clay slates are converted to gneissoid mica-schists. The zone of metamorphism extends at least three-fourths of a mile northward from the contact.

GNEISS OF ST. MARYS PEAK.

Eighteen miles south of the northern end of the range, St. Marys Peak rises to an elevation of 9,300 feet or 6,000 feet above the level of the valley. As usual in these mountains the culminating points are situated a few miles east of the main divide. The long ascent from the valley leads over the usual sheared granite of the front of the range, with its constant easterly dip. But at about an elevation of 7,000 this changes without clearly exposed contact to a very contorted and entirely different gneiss, very rich in black mica and weathering with reddish color. Streaks and patches with fairly well-marked outlines of fine-grained, also contorted, mica-schist are embedded in this. These rocks have, on St. Marys Peak, a northerly strike and a westerly dip of about 70°. The area clearly extends southward across Big Creek. As evidenced by the detritus brought down to the valley by the creeks, similar rocks also occupy considerable areas to the north of the peak. A short distance westward the normal granite begins, and is well exposed in the glaciated outcrops. The age and origin of the St. Marys gneiss has not been determined. A possible explanation is to consider it simply as an extreme facies of contact metamorphic action on the Lolo series, and this view receives some support from the fact that small amounts of somewhat similar rocks were observed at the Carlton Creek contact. But the area is too uniform and large and the absence of quartzites is too conspicuous to allow this explanation to stand. Considering the relations in the southeastern and southwestern parts of the Clearwater Mountains, it is more probable that it is an independent and older gneiss, very likely of Archean age, which underlies the Lolo series and which, like those beds, was invaded and ruptured by intrusive granite.

GRANITE; QUARTZ-MONZONITE.

A granite of the normal appearance of the Bitterroot variety occupies the drainage basin of Lolo Fork, above Hot Springs, and of Granite Creek. The rock which near the Springs forms light-gray, large, partly rounded, outcrops of typical form, is coarse grained and contains both biotite and muscovite. An analysis would probably bring out its close relationship to quartz-monzonite. It contains much grayish orthoclase, besides perthite and a little microcline as well as an acid oligoclase. The character seems constant as far as observations were extended. A few miles west of Lolo Pass a few outcrops of pyroxenite were noted; beyond this the normal muscovite-granite begins again, and from the appearance of the outcrops, seems to occupy the whole of the last end of Lolo ridge in the Clearwater Mountains and the larger part of the country visible to the south of the Lochsa Fork, including the prominent mass of Grave Creek.

QUATERNARY.

The only deposits belonging to the Quaternary period, noted in the Lolo drainage, are the narrow meadow lands appearing at intervals in the usually flat bottom of the Lolo Fork and the high terrace near Sparks's ranch. While in the lower part of the stream no gravel terraces were observed, an extensive bench of coarse gravel, deeply cut by the river and its gulches, forms a prominent feature near the junction of the first important branch from the north, 14 miles above the mouth of the river. Steep declivities lead up from the bottom lands to this terrace, which probably occupies an area of several square miles on both sides of the river. The well-washed gravel begins at an elevation of 400 feet above the stream and reaches up to 550 feet (elevation 4,300 feet); above it rise long, gently sloping ridges of slate and other sedimentary rocks.

This occurrence is interesting as it shows that during some part of the Quaternary period Lolo Fork, like the main Bitterroot River, was filled by sands and gravels to an elevation several hundred feet above the present river bottom.

No evidence of glaciation was noted along Lolo Fork, though it is probable that the ice streams of the Bitterroot Range extended westward to a point near Lolo Pass and that the meadow lands at that place are of glacial origin.

BITTERROOT RANGE.

TOPOGRAPHY.

As defined in this report, the Bitterroot Range extends from the head of West Fork of Bitterroot River and the Nez Perce Pass on the south a distance of 65 miles almost due north to Lolo Fork. Its imposing front, with deep canyons and snow-flecked serrated ridges, overlooks the Bitterroot Valley on the east, while westward its slopes soon merge into the dissected high plateau of the Clearwater Mountains. Its height is considerable, though many ranges of the west easily exceed it in this respect. Near the southern end El Capitan and Trapper Peak nearly reach or exceed 10,000 feet, but the average elevations of its highest summits is more nearly 9,000 feet. These elevations are very constant throughout the range, which thus rises somewhat less than 6,000 feet above Bitterroot Valley. North of Lolo Peak and south of Boulder Peak the elevations decrease conspicuously, few points exceeding 8,000 feet south of the Boulder Peak or 7,000 feet north of Lolo Peak. The range is characterized by some very singular and constant topographic features, of which the most striking, perhaps, is the regular and even slope toward the valley. From Lolo Peak to Nez Perce Pass this slope is nearly constant at angles ranging from 18° to 26°. Its width varies from 2 to 4 miles. Pls. IV, VI, *B*, VII, *B*, IX, *A*, and X and figs. 2 and 3 show the appearance of this slope from various points in the valley. From the summit of this slope, east-west ridges extend toward Clearwater to the divide which forms the boundary line between Montana and Idaho. These ridges are usually narrow, extremely jagged, and rough, but their highest peaks do not vary much in elevation. In some places, as near Ward Peak (Pl. III), the highest elevations of the range are nearer to the valley than to the main divide. Ordinarily, however, the highest summits of the range are halfway between the valley and the divide, the peaks along the divide never reaching 9,000 feet and ordinarily ranging in elevation from 7,500 to 8,500 feet. The saddles on the divide are from 7,000 to 7,500 feet in elevation, except in the case of the gap at the head of Lost

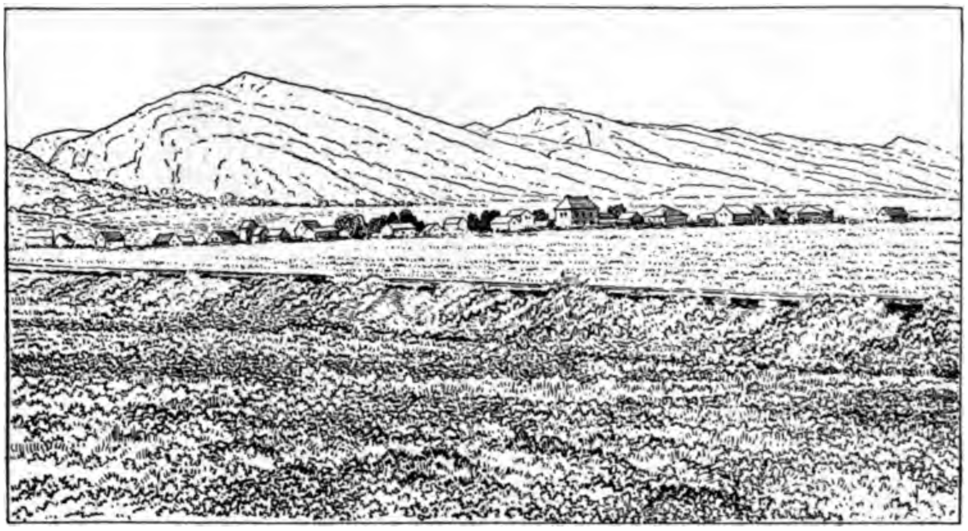


FIG. 2.—Bitterroot Range, looking northwest from Hamilton: showing gentle eastward dip of gneiss zone and deeply incised canyons of Blodgett and Mill creeks, with precipitous sides.

Horse Creek, which sinks to 6,600. Both Lolo Pass and the Nez Perce Pass are still lower, the former only attaining 5,300 feet. Thus the summit of the range lies several miles to the east of the Clearwater divide. (See profiles, Pl. IV.)

Another remarkable feature is in the direction and character of the drainage. Seen from any convenient place in the valley, for instance, from Grantsdale, the bold, even slope sweeps along the face of the range as a single tectonic plane; the canyons, like those of Blodgett and Mill creeks, appear as deep gashes, scarcely interrupting the continuity of the front. They are narrow, especially near the mouth, the walls in many cases being abrupt precipices. About twenty canyons, closely spaced, score the east slope of the Bitterroot Mountains. In most cases their streams are remarkably straight, flowing from west to east, without important branches, and separated by almost equally straight ridges, with narrow, jagged summits. Especially fine instances of this arrangement are furnished by the four or five creeks west of Hamilton. (Pl. III.) Broadly U-shaped in their upper courses (Pl. VII, *A*), due to energetic glacial action, they generally narrow to V-shaped incisions near the mouth. Near the head we note a general tendency to turn southward. By far most of their tributary gulches are received from the south, while the slopes to the north of the canyons generally present unbroken fronts. Lost Horse Creek is rather an exception to the rule, as it splits, not far from the mouth, into three branches. Along the main divide and sometimes also on the secondary east-west ridges small glacial lakes are found in abundance.

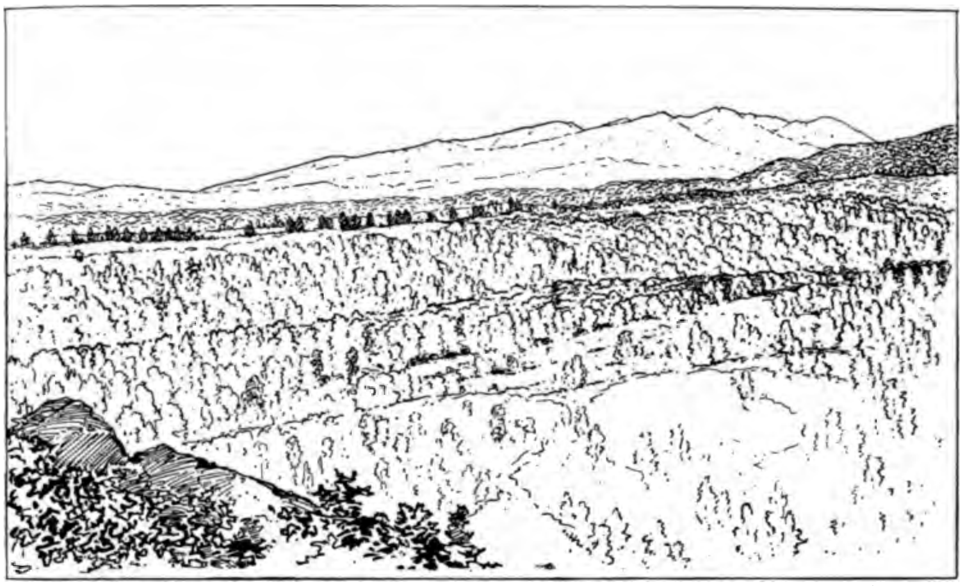
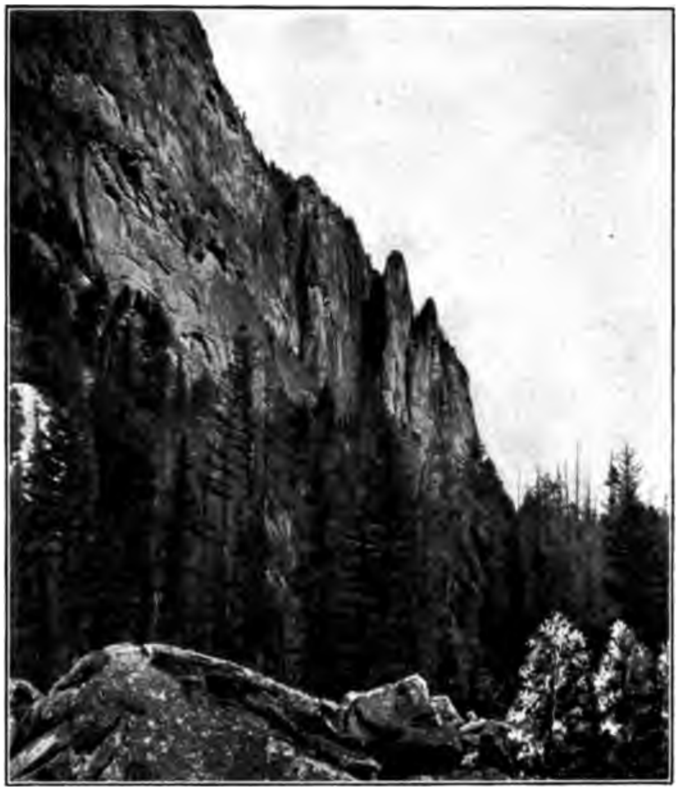
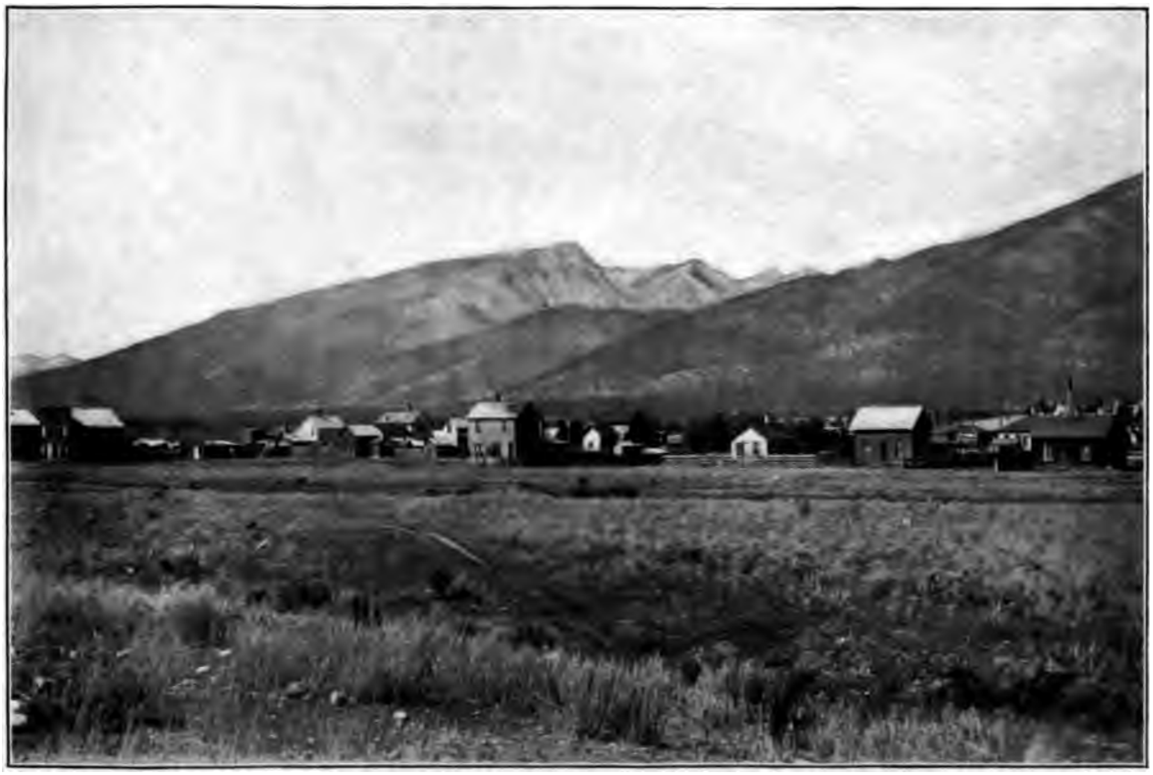


FIG. 3.—South end of Bitterroot Range from point near Darby; showing gradual eastern slope of gneiss zone south of Tincup Creek. Moraines are shown in foreground.



A. DETAIL OF GNEISS CLIFF ON NORTH SIDE OF MILL CREEK CANYON, NEAR MOUTH.

Cliff 1,500 feet high.



B. VIEW SOUTH FROM HAMILTON.

Shows regular slope of gneiss zone of Bitterroot Mountains. Ward Peak is seen in the center background, and below it the ridge between Roaring Lion and Sawtooth creeks.

Jointing of the rock, erosion, and glacial action contribute to an excessive roughness of topographic detail, making the range one of the most inaccessible. Continuous travel along the divides is impossible, on horseback or on foot. In the creek bottoms, treacherous, swampy areas, a slender but impenetrable growth of lodgepole pine, tangled underbrush, and fallen logs make travel difficult, even along the few trails which cross the range or ascend the gulches. Between Lolo and Nez Perce passes the only safe horse trail across the range is that leading up Lost Horse Creek, and even this is far from being an easy one.

Ordinarily mountain ranges adjoining thickly populated valleys abound in trails or even roads, and are well known and frequented by the inhabitants of the plains. But the Bitterroot Range is different; its lofty summits are without the attractions of flowery meadows and easy paths; only the hunter and the explorer penetrate its wilderness. The lower slopes are covered by thick forests which gradually become more sparse as elevations increase and the white granite begins to gleam between the dark pines; finally vegetation almost ceases and the summit region spreads out with a maze of peaks and broken ridges of dazzling bright granite, flecked by still more brilliant snow fields. (Pls. VII, *B*, and VIII, *A*.)

The main divide, distant from 8 to 15 miles from the first foothills, is, as stated above, a succession of sharp, craggy peaks alternating with deep saddles at the head of the large canyons. Especially in the southern portion of the range it is irregular, swinging from east to west with curves the radius of which is from 1 to 2 miles. On a smaller scale the same thing is repeated on the secondary east-west divides of the eastern slope, the secondary canyons cutting deep recesses in them, narrow, precipitous of grade in their lower part, and opening into wide glacial cirques near their head.

The western slope of the range is even more rugged than the eastern. "The immediate slopes from the crest are here very abrupt, are cut up by immense gorges, and abound in precipices and extensive rock slides to such a degree that they are entirely impassable."[a] Westward these ridges soon descend to the level of the dissected high plateau of the Clearwater Mountains, and the glacial cirques contract to the winding, narrow, and inaccessible canyons of that system.

GEOLOGY.

SEDIMENTARY SERIES.

Except near its extreme northern end the Bitterroot Range is almost exclusively built up of granite and gneiss. The Lolo sedimentary series and the St. Marys gneiss have already been described in the preceding section. South of Carlton Creek no sedimentary rocks are known from the interior mass and only a few smaller areas have been observed along the first foothills.

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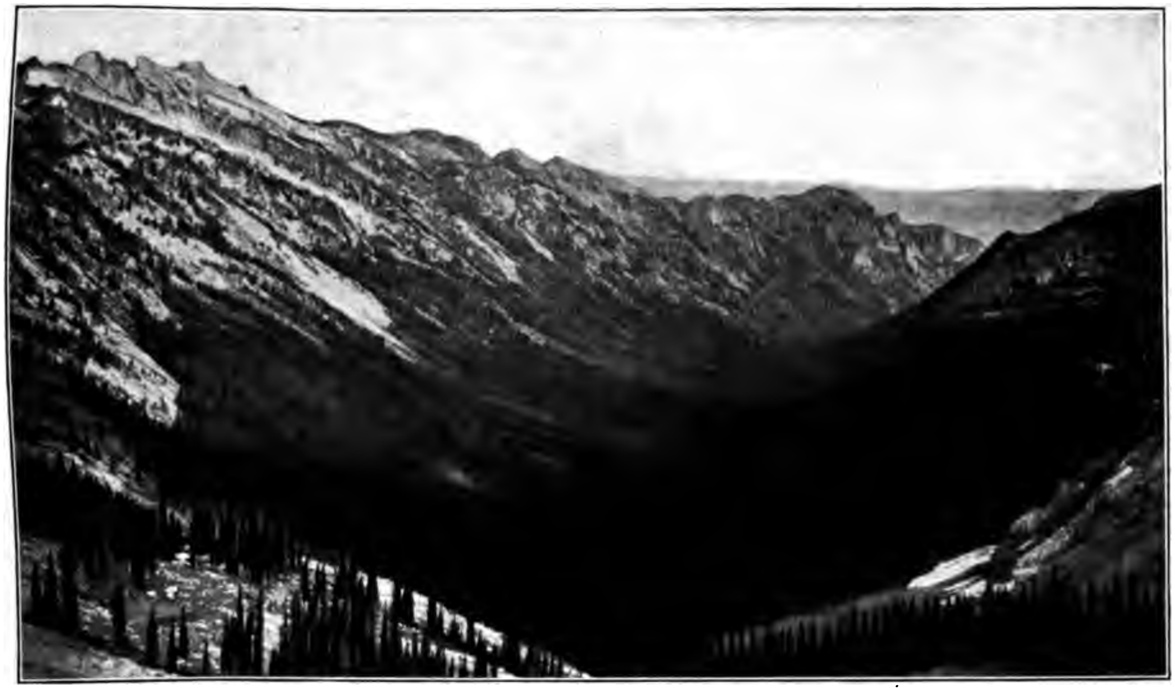
[a] Leiberg, J. B., Twentieth Ann. Rept. U. S. Geol. Survey, pt. 5, 1900, p. 319.

The largest sedimentary area is that near Curlew mine; it occupies less than 2 square miles and really forms foothills projecting beyond the normal line of the base of the range. It begins just south of Big Creek and continues southward for 2 miles, having an average width of half a mile. The rocks, which are not very well exposed, are chiefly quartzite, or calcareous quartzite, in places converted into a fine-grained, dark-brown, contact-metamorphosed hornfels. Throughout the rocks are exceedingly crushed and broken, and rarely show their strike and dip. At one place, on the ditch toward Big Creek, was noted a dark lime shale with a southwesterly dip of 60°. On the west the contact with the gneiss runs nearly straight north and south and is a fault plane. A dislocation occurred along this line in 1898 and is still visible on the surface of a gently sloping ridge. It extends for 1,500 feet and is partly an open fissure, the downthrow being on the eastern side and amounting to 1 or 2 feet.

No well-defined sedimentary rocks have been found along the foothills for a long distance south of this area. Near the mouth of Sawtooth Gulch fine-grained rocks occur interbedded with the ordinary gneiss, but they seem only to be varying dynamo-metamorphic developments of granites of slightly differing texture. Between Chaffin and Tincup creeks, near the south end of the range, extends a short ridge parallel to the trend of the mountains and of somewhat complicated structure. Much of it is made up of a fine-grained, almost flinty rock, largely consisting of quartz; this has a bedding or jointing, dipping 40° east. The same ridge also contains a coarse gneissoid rock, roughly schistose, and similar to the imperfect gneisses east of Darby. The schistosity strikes east-west, and the dip is 30° north; some of this gneiss is of fine grain.

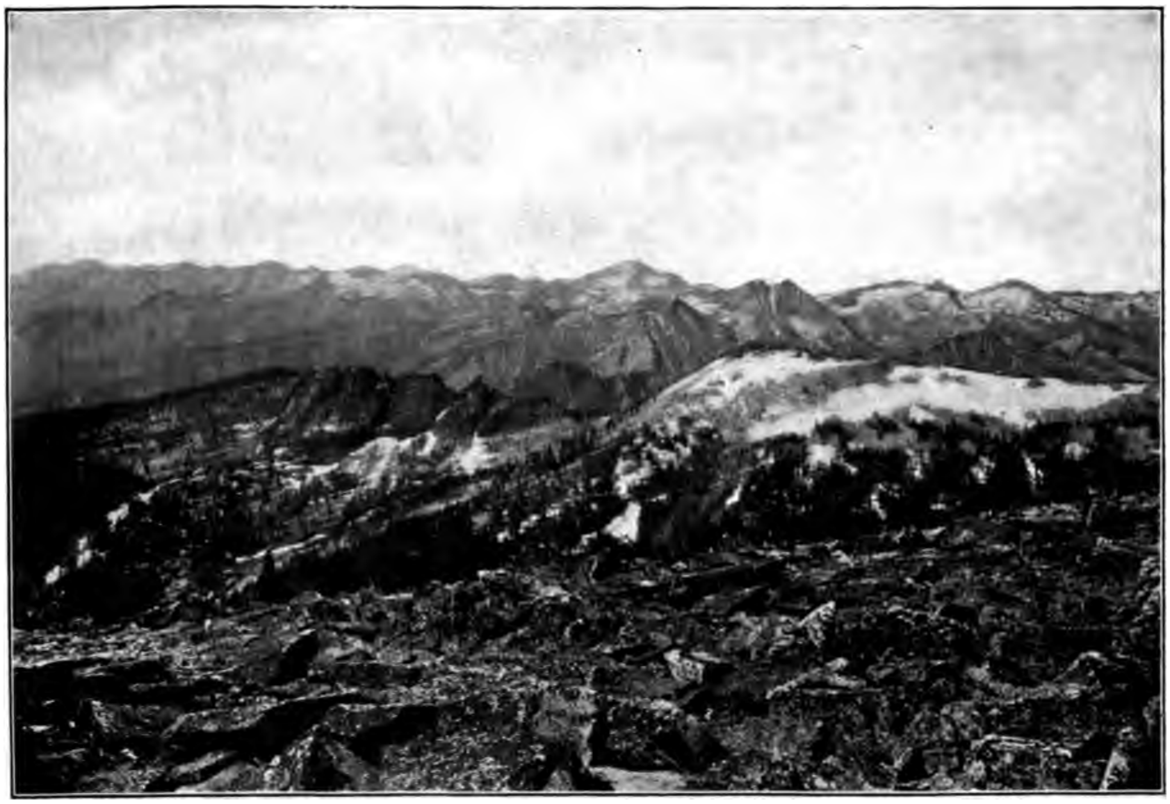
GRANITE AND GNEISS.

It has already been stated that the range almost entirely consists of granitic and gneissoid rocks. The arrangement of these corresponds to the topographic development described above in this manner: The central mass is almost throughout a normal biotite-muscovite-granite; the regular eastern slope, even and continuous from Nez Perce Pass to Lolo Peak, is formed by a sheet of gneiss, dipping from 18° to 26° E. like that slope. The gneiss is a modification of the interior granite—in other words, is granite made schistose by pressure, and westward gradually changes into the massive granite. This gneiss is not only schistose, but also full of slipping planes, parallel to the schistosity, and on these slipping planes are commonly closely massed striations parallel to the dip of the gneiss. The structural importance of these remarkable facts will be discussed in a later paragraph (p. 47). In this place such detailed observations as are available will here be recorded.



A. UPPER VALLEY OF MILL CREEK, BITTERROOT RANGE, LOOKING EAST FROM MAIN DIVIDE.

Note pronounced U-shape of valley, narrowing toward the lower part. The prevailing rock is granite.



B. VIEW SOUTH FROM WARD PEAK, BITTERROOT RANGE.

El Capitan in center background.

North end of the range.—Going from north to south the gneiss is first observed at the mouth of Carlton Creek Canyon. It is here imperfectly schistose, dipping 15° to 18° E., and the belt is not wide.

Two miles farther up normal granite crops on the south side. As described on page 36, the gneiss borders the quartzite of the Lolo series, and the contact shows it to be of intrusive character.

A few miles farther south, due west of Florence, the gneiss has locally a steeper eastward dip of 30° to 35°, and fine cliffs of these rocks are seen, where the canyon walls cut the front plane of the range, 2,000 feet above the valley. Large white granite cliffs appear higher up in the canyon. The exposures in the lower part of Big Creek along the Curlew mine ditch are excellent; the gneiss dips 20° E., striking a few degrees east of north exactly parallel to the local trend of the foothills; the rock is medium-grained, dark gray, and very much sheared, the larger feldspars being pressed into lenticular shape and surrounded by films of fine-grained biotite. Striated slipping planes are very frequent, the striations being strictly parallel to the dip of the gneiss; large foils of secondary muscovite have in many places developed on the planes of schistosity.

At Bear Creek a small area of massive granite lies in the first foothills, but immediately west of this the normal gneiss begins and is well exposed with easterly dip of 18° at the entrance to the canyon, above the moraines.

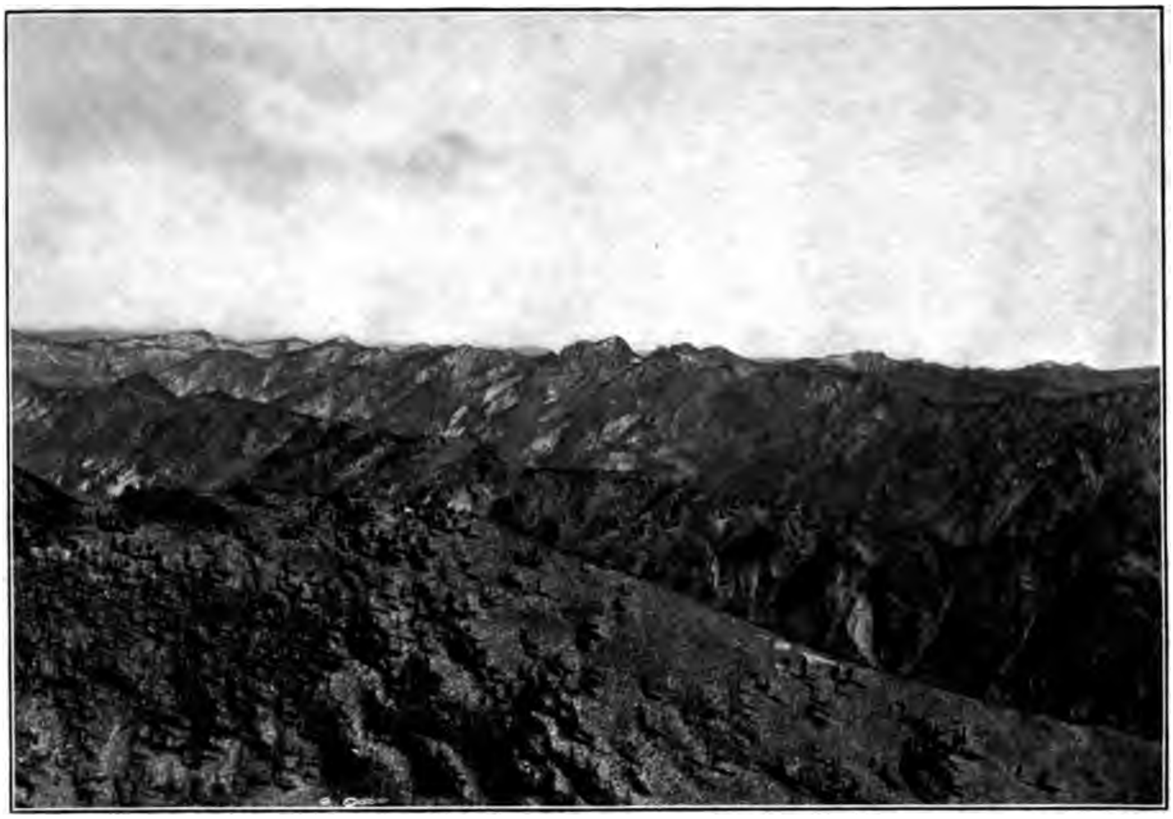
Mill Creek section.—A good section is obtained along Mill Creek, the almost perpendicular bluffs of the lower canyon offering excellent opportunities for observation. The dip of the gneiss is from 15° to 25° E., probably averaging 18°. It seems a little steeper near the valley and flattens out slightly toward the west. Horizontally the width of the gneissoid zone is 1½ miles, corresponding to a thickness of about one-half mile. In petrographic character the gneiss is similar to that from all points described above. It is medium to coarse grained, consisting of elongated aggregates of gray feldspar and quartz separated and surrounded by streaks of black and white mica. Striated slipping planes are very common, as are also elongated pressed orthoclase crystals up to 1 inch in length. As the canyon is ascended the gneissoid structure becomes less apparent and about 2 miles above its mouth, where the whole bluff is beautifully exposed, the bottom is in granite and schistosity sets in by degrees toward the top. Much of the gneiss has the same grain as the granite; some layers are, however, finer grained and darker in color. This is clearly not due to any diversity of material, but only to the degree of crushing and compression. Some layers are so much sheared as to constitute a dark slaty mass traversed by innumerable wavy slipping planes. The petrographic examination, as well as that in the field, allows no doubt as to the original identity of granite and gneiss. From this point westward to the divide and far beyond it granite is the only rock present. The prevailing variety is medium to coarse grained, the average size of the grains being about 5 mm.; it contains much grayish quartz and whitish orthoclase or perthite and oligoclase, and besides small quantities of both biotite and muscovite in small foils, the former usually prevailing. Porphyritic orthoclase crystals up to 1½ inches in length are of frequent occurrence. The outcrops are brilliantly white; the rock weathers with a thin hard and white crust, fresher in appearance than the inside, the softer texture and slightly yellowish color of which becomes apparent when the surface is broken off the large glaciated outcrops. The granite in many places contains many streaks ("schlieren") and masses of darker, finer grained rock, with more biotite and sometimes rich in titanite. Usually they appear as if kneaded into the normal rock and exhibit a pseudo-schistose, contorted appearance probably due to fluidal structure. These masses are probably more basic, differentiated, and early cooled parts of the magma. Pegmatitic masses and dikes of all descriptions are conspicuously absent.

An east-west perpendicular jointing of the gneiss zone is a very common feature, producing the perpendicular walls of the canyons. In the granite the same structure is not so persistent. There is much jointing, to which the pinnacles of the ridges are largely due, but no striking regularity is exhibited. On glaciated outcrops an exfoliation is often noticeable, causing the surface to scale off in concentric, slightly curved slabs.

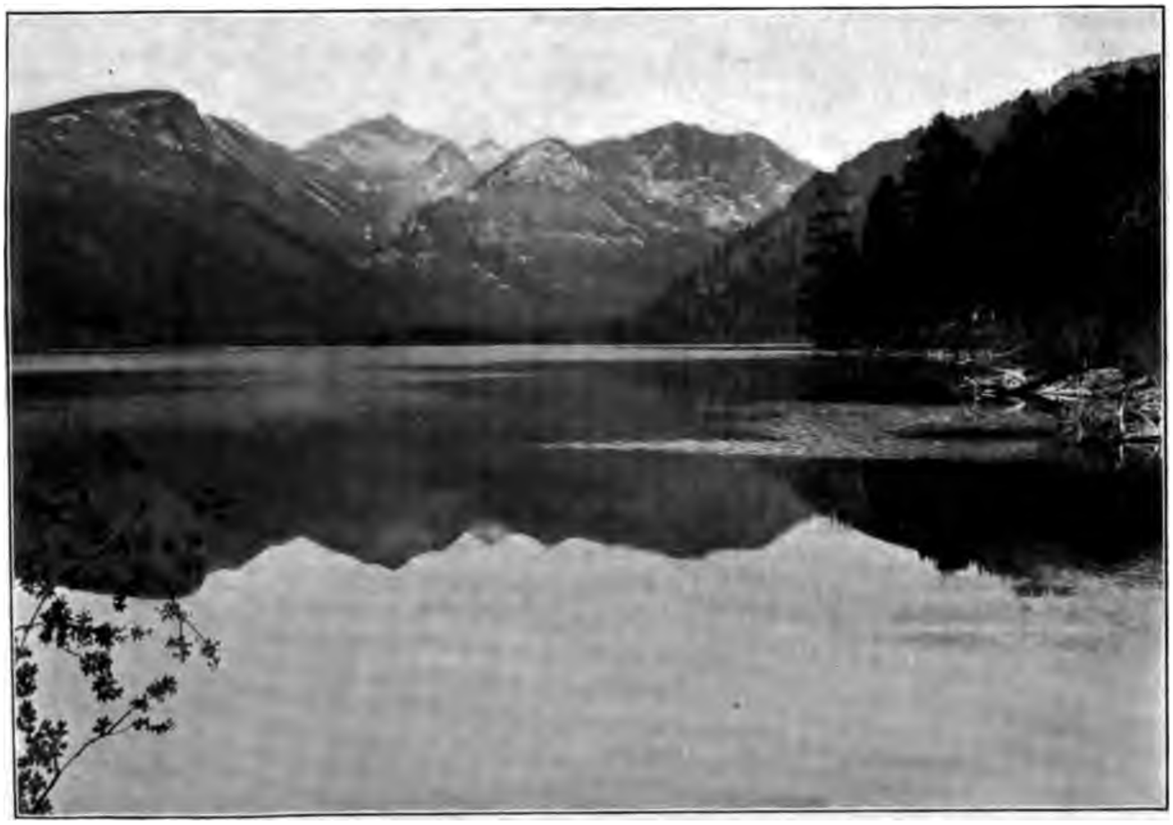
Like most of the canyons, Mill Creek bends south near its source and a small glacial lake, surrounded by a cirque of bare granite cliffs forms its head. On ascending this cliff, which is about 1,000 feet high, an excellent view is obtained over almost the whole extent of the Clearwater Mountains. The bare, glaciated outcrops seen in the maze of sharp peaks and serrated ridges northward as far as Big Creek and southward as far as Lost Horse justify the conclusion that the whole range is built up of granite. Westward the same kind of outcrops are seen on successive ridges as far as Grave Peak, which is a prominent granite point rising from a lower forested plateau. Rhodes Peak and at least parts of the Lolo Ridge appear to be of the same material. Similiarily, The Crags are clearly of granite. The whole gives a remarkable illustration of the extent of this rock.

Gneiss of usual structure and dip of 18° to 20° E. appears in the lower parts of Roaring Lion and Sawtooth creeks and numerous granite bowlders give evidence of the prevalence of this rock in the upper parts of the canyons.

Lost Horse section.—West of the heavy moraine piled up at the mouth of Lost Horse Canyon a high cliff of gneiss appears on the north side. The rock has the same structure and appearance as described above, but the dip is distinctly less. On the first cliff it is only 5° E. As usual many striated slipping planes lie parallel



A. VIEW NORTH FROM WARD PEAK, BITTERROOT RANGE, ACROSS CANYONS OF ROARING LION AND SAWTOOTH CREEKS.



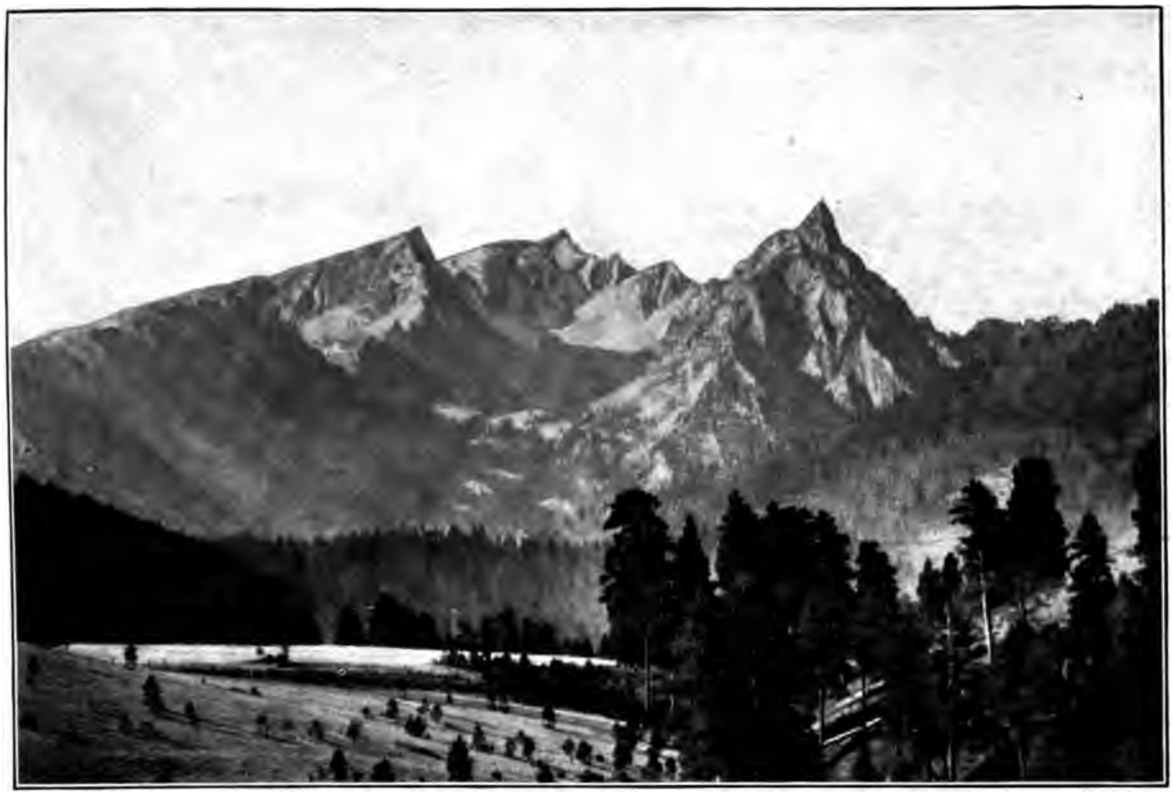
B. COMO PEAKS FROM COMO LAKE, BITTERROOT MOUNTAINS.

Trapper Creek section.—A few miles south of the forks of the Bitterroot, Trapper Creek empties into the South Fork after a short course of about 6 miles, the eastern slope of the range narrowing considerably south of Tincup Creek. Trapper Creek heads among the cirques of the peak of the same name, the highest elevation in the range (Pl. IX, *A*), and a heavy moraine has accumulated in front of its canyon. Near its mouth the prevailing rock is the granite of the eastern foothills (p. 32), cut by frequent dikes of granite-porphyry. This continues for one-fourth of a mile above the mouth. The moraines, containing some gneiss but chiefly granite bowlders, cover the underlying formation; 3 miles up from the main river the first high bluffs on the north side consist of gneiss, partly normal with the characteristic drawn-out feldspar crystals, partly more crushed and chloritic; a few slipping planes with usual direction of striations were observed. The dip averages 15°, but varies in detail from 10° to 40°. One mile farther up there is no gneiss in the lower outcrops, but only a coarse granite, while the débris fallen from the top of the bluff still consists of gneiss. The granite shows a few joint planes dipping 20° E. From points well up on the slope fine views are obtained up toward the sharp peaks and cirques at the head of the creek, all apparently granite, while the front slope of the range, beautifully shown by its line of intersection with the south side of the canyon trench, clearly consists of a sheet of gneiss gradually carried up to points with elevations of about 8,000 feet. Beyond, the cliffs break off westward and granite prevails.

South end of the range. South of Trapper Creek the strike of the gneiss sheet swings to north-northeast, the dip remaining the same or about 15° (fig. 3). The even slope of the frontal plane is carried up at this angle to the very divide, the descent to the Bitterroot River being here less than 6 miles. The deeply incised Boulder Canyon is passed 8 miles above Trapper Creek; in a few miles more the West or Nez Perce Fork is reached. This valley opens up wide and broad in contrast to the narrow canyons of the main river, or South Fork, above the junction, and from high points in this vicinity a most interesting view is obtained, showing the manner of termination of the range. At the junction of the forks and for several miles along the West Fork, which is followed by the Nez Perce trail, massive granite prevails, penetrated by many dikes of granite-porphyry.

From the vicinity of Boulder Creek the front plane of the range begins to swing in a still more easterly direction, but is continued with the same general dip and forms the whole northern slope of the West Fork Valley.

The first creek coming down this slope about 2 miles above the junction of the rivers was ascended by Mr. Stose, who found the first outcrops about 800 feet above the valley. Here the normal Bitterroot gneiss is encountered with a strike of N. 52° E., and a dip of 40° SE. Besides this, there is a rough bedding dipping S. SW., and joint planes with evidence of slipping, which strike N. 75° E. and dip steeply to the north.



A. TRAPPER PEAK, SHOWING GRADUAL SLOPE OF GNEISS ZONE TO THE LEFT AND GLACIAL AMPITHEATER IN CENTER.

B FOREST OF LODGEPOLE PINE (PINUS MURRAYANA), COMO TRAIL, BITTERROOT MOUNTAINS.

Beyond this point the frontal plane is seen to continue for several miles farther west, turning gradually to an almost east-west strike. Gneiss appears to occupy this whole slope to the summit or main divide and the dip of the schists is clearly seen to conform to the slope of the plane. Toward the head of the West Fork it appears as if this gneiss gradually merged into the prevalent granitic mass. This is the conspicuous southern termination of the Bitterroot Range. South of the West Fork geology and topography undergo a complete change.

STRUCTURE AND PHYSIOGRAPHY.

The topographic description of the range has shown the existence of a most persistent plane dipping 15° to 26° E., which forms the slope inclined toward the valley, and which continues with due north-south direction from Lolo Peak to Boulder Creek, where at the southern end of the range it gradually swings westward, retaining the same dip, now turned southerly. A short distance west of the bend the plane appears to die out. It can not have been produced by erosion, and the only alternative is to consider it as a structural plane. An examination of the geology reveals the fact that this plane is formed by a layer of gneiss, which petrographic methods show to have been derived by compressive or shearing stress from the normal massive granite forming the mass of the range. The gneiss zone conforms in strike and dip with the structural plane, and moreover shows persistently and uniformly, by little slickensides and striations, evidence of a movement parallel to the dip of the gneiss and the structural plane. The aggregate movement along all these slipping planes may well have been very large. While the gneiss zone usually is thin, and ordinarily less than 3,000 feet in width perpendicularly to the strike plane, it flattens in the Lost Horse section, and a roughly gneissoid granite with nearly horizontal schistosity extends westward at this place as far as the main divide. The strongest schistosity and the most closely massed slipping planes always occur farthest east along the structural fronting plane.

The only conclusion which can be drawn from these facts, remarkable and unique as far as my knowledge goes, is that a uniform dislocation of great extent has taken place all along the east slope of the range. The main dislocation was accompanied partly by direct movement on minute and numberless fault planes (slipping planes) and partly by molecular movements long enough sustained to produce a typical schistose structure within the affected zone. The unusual feature in this dislocation is the intimate combination of actual fault planes with schistose structure, showing in the clearest manner, to my mind, the transitions between schistosity and jointing, and between molecular and molar movement, and indicating that both result from the same force. Taking all the data into consideration, it does not seem as if the depth at which this schistose structure was produced could have been more than a few thousand feet at the utmost. Any attempt to place the formation of this schistosity at great depths from the surface must lead to wholly improbable depths of erosion and amplitude of faulting movement. Another unusual feature consists in the flat dip of the fault plane; this flat dip is no doubt the cause of the remarkable topographic preservation of the fault plane.

The minimum of actual movement on the fault plane is clearly measured by the width of the gneiss zone along this plane from the summits to the base of the mountains, a distance of 2 or 3 miles. The vertical component of this movement would be 4,000 to 6,000 feet, and this again must be considered as a minimum.

Admitted that we have here a flat fault of great extent, the next question is as to the absolute direction of the movement. That the relative movement took place parallel to the dip of the gneiss is clear beyond question from the observed facts. It was first thought that the deformation of feldspar crystals in the gneiss would elucidate this problem. No satisfactory answer was obtained in this way, though more detailed studies perhaps would be productive of better results. The deformation of the crystals seemed to have proceeded under such heavy pressure that a flow rather than a break resulted, and it was impossible to tell whether the hanging wall had relatively moved up or down. The slickensided slipping planes, on the other hand, never break across a crystal, but follow in gentle curves the aggregate of recrystallized mica scales, on which, of course, the movement was most easy.

Approached from a different direction some elucidation of this problem might possibly be attained. Throughout the Salmon River Mountains, as well as in the Clearwater and the Coeur d'Alene mountains, the configuration of the ridge lines shows that they may be considered as the remnants of a gently undulating plateau raised by epeirogenic forces and dissected by active erosion. The average elevation of this wide plateau of central Idaho is perhaps 7,000 feet. It extends far north and south of the Bitterroot Mountains, which stand as a boldly raised block 1,000 to 3,000 feet above this level. It seems unavoidable to connect this uplift with the fault at the base of the range, and thus we arrive at the conclusion that the foot-wall side of the fault has been raised relatively to the hanging side; in other words, the fault is a normal one. Considering again that the Bitterroot Valley is an extremely well-marked and probably very deep depression almost coextensive with the range, and that borings would probably show it to be a structural depression without outlet, we come again to the conclusion that the hanging has subsided relatively to the foot of the fault; in other words the fault is probably a normal one.

There are interesting facts which prove that this subsidence has taken place and that it has not even yet ceased. At the Curlew mine, located in the first foothills pretty clearly that gravity does not alone suffice to explain this movement, for as pointed out by Mr. G. F. Becker,[a] friction would overcome gravity on a slope of the fault plane of 45°.

In presenting these conclusions I am not unmindful of the cursory character of the field work and fully appreciate that more detailed examinations will throw a much more vivid light on the extremely interesting questions of mountain building and rock structure involved. The main facts seem so plain, however, that they scarcely admit of any other interpretation than that advanced. It is believed that the Bitterroot Range will always remain one of the most important localities in the world for the study of the development of schistosity and distributed faults.

It seems unavoidable to recognize the intimate and inseparable relation between schistosity and faulting, or, in other words, between molecular and molar rock movements, in the sheared zone of the Bitterroot Range. The striated slipping planes of the granite-schist are often very closely massed, as many as twelve of them sometimes occurring in a thickness of an inch. Their surfaces are covered with micaceous aggregates or large, new-formed flakes of muscovite, and they curve gently about the lenticular, pressed aggregates of former larger feldspar or quartz grains. The latter are sometimes broken by a series of small fissures inclined about 45° to the plane of schistosity and filled with secondary quartz. (Pl. V, *A*, *B*.) Many of the slipping planes form blind joints, nonpersistent or gradually fading.

The two differing views of the relation of schistosity and jointing may be briefly recalled: Mr. Van Hise holds[b] that the two are distinct phenomena. In the upper or "zone of fracture" of the earth's crust, bedding fractures, faults, joints, fissility, etc., are formed almost wholly by the breaking of individual minerals and by differential movements between them. Rock flowage, producing schistosity, mainly occurs in a very deep-seated zone by innumerable fractures of the mineral particles, or by recrystallization; in brief, it is a molecular movement in which mass fractures play a subordinate part.

On the other hand, Mr. G. F. Becker[c] holds that there is no essential difference between jointing, cleavage, and schistosity, all of those phenomena being due to weakening of the cohesive force on planes of maximum slide or maximum tangential strain. Accordingly, schistosity and jointing, molecular and molar movement, may both be produced at the same time, and molecular movement is not necessarily confined to great depth. The observations in the Bitterroot Range seem to confirm Mr. Becker's views.

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[a] Bull. Geol. Soc. Am., vol. 4, 1893, p. 47.

[b] Van Hise, C. R., Principles of North American pre-Cambrian geology, with an appendix on flow and fracture of rocks as related to structure, by L. M. Hoskins: Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 589.

[c] Becker, G. F., Finite homogeneous strain, flow and rupture of rocks: Bull. Geol. Soc. Am., vol. 4, 1893, pp. 13–90.

Nez Perce Fork, or West Fork, at the southern terminus of the range, is free from glaciation, and no evidence of anything but very local accumulations of ice were noted upon the headwaters of the South Fork south of Nez Perce Pass.

The U-shaped form of the valleys, the moraines accumulated in front of their canyons and within their troughs, the polished outcrops of granite throughout their extent, all bear undoubted testimony to the existence of this ice sheet. The main canyons as well as the tributary gulches terminate everywhere in glacial cirques. In short, all the familiar phenomena of extensive glaciated areas are represented in the Bitterroot Range on a grand, instructive scale. Only the highest peaks and ridges appear to have projected above the general level of ice and sand and between the projecting glacier tongues. The foothills of the range also rose to an elevation of 2,000 feet above the valley below the line of permanent snows.

Not in all cases did the glaciers extend down to the mouth of the canyons where they opened on the valley. There is clearly evidence of increasing strength of the glacial action toward the southern end of the range. Here large morainal masses several square miles in extent and with ridges sometimes a thousand feet in height lie in front of the foothills.

Beginning from the north, the Carlton Canyon was first examined. The canyon pass is narrow and V-shaped, and it is doubtful whether any of the material in front of it is of true glacial origin. Heavy masses of bowlders lie on both sides of the canyon at its mouth and extend in fan shape for a distance of half a mile. Possibly these accumulations are the result of local cloud-bursts or torrential action.

At the mouth of Big Creek Canyon the gravel terraces extend up to the foothills of gneiss, and there are no accumulations of bowlders in front of the canyon. Its lower part is V-shaped and sharply incised without polished outcrops or other indications of glaciation.

At the mouth of Mill Creek Canyon a sloping plain of gravel and sand extends down to the river 400 feet lower. Over this gravelly slope Mill Creek flows in a shallow cut at most 30 feet deep.

The first signs of glacial action are seen at Sears's ranch, near the foothills, and consist of a big pile of granite bowlders, some of them 8 feet in diameter. A very heavy moraine lies on the south side of the creek near the same place and close to the mouth of the canyon. The surface forms of these bowlder masses indicate unquestionably their morainal origin. Little ridges and shallow ponds abound. The height of this moraine is several hundred feet, and on its southern side no rock in place appears for a distance of half a mile farther west, while on the northern side outcrops begin much lower down. Near the mouth the canyon presents no

of these rise the jagged peaks and ridges of granite and gneiss. Pl. I shows the areal extent of the heavy moraines of the south end of the range. At the mouth of Lost Horse Canyon moraines occupy several square miles, the most prominent one forming an 800-foot ridge on the south side, reaching up to an elevation of 5,000 feet. The creek has cut through the terminal moraine, and gravel terraces skirt the east front of the moraines 200 feet above the river. The canyons of the forks of Lost Horse Creek are practically duplications of those of Mill Creek, the bottoms being U-shaped and often showing extensive and smooth surfaces of ice-worn granite, and elsewhere occupied by a thick growth of lodgepole pine. The sides are precipitous cliffs with many enormous rock slides. Near the head of the Middle Fork lies a heavy bottom moraine which has dammed the Twin Lakes at Lost Horse Pass.

In a similar manner, high lateral moraines have been piled up on both sides of Rock Creek. The terminal moraine has been partly cut through by the stream, but above it still lies the beautiful sheet of water dammed by it, which is called Como Lake. From its pine-clad shores a magnificent view is obtained up toward the jagged summits of Como Peak, 5,000 feet above the lake. (Pl. VIII, *B.*) At the mouth of Tincup Canyon similar though smaller moraines have accumulated. The ice stream was deflected southward, so that the lateral moraine on the north side swings around in a graceful curve.

From this point southward the distance to the main divide is less, and the glaciers were correspondingly smaller.

The moraines of Trapper Creek form a fine semicircle, opening southward. They are 3 miles long and 300 feet high, and extend almost to the Bitterroot River. The last large tributary from the western slope of the Bitterroots is Boulder Creek, the moraines of which project to the river and have forced it to cut a cliff in the eastern foothills.

The 200-foot gravel terrace skirts the moraines down to the junction of the two main forks of the river and continues for some distance up the East Fork, while the South Fork south of Chaffin Creek enters a narrow canyon.

From all appearances, the glaciation of this range extended to a very recent date. While in all cases, excepting Rock Creek, the principal creeks have trenched the terminal moraines, but little evidence of erosion is to be seen beyond this cutting, and in many places higher up these torrential streams still flow over broad and flat glaciated outcrops, not yet having had time to excavate new canyons in them. The surface of the moraines is often remarkably smooth, due no doubt to the sandy and crumbling character of the granite, and is generally covered by a fine growth of yellow pine.

On the western side of the range the glaciers must have been still more extensive than on the slope facing east. The canyon system is here more branching; the precipitation was also probably heavier. The result would be that several ice streams would meet, and, coalescing, extend far down into the Clearwater drainage. Just how far west they reached has not been ascertained, but from the available information as to the size of the glacial cirques at the summit and the conditions of the rivers farther down it is probable that along the Lochsa, Moose Creek, and Selway forks this distance was about 20 miles from the main divide. Very likely the névé fields of the northern part of the Bitterroots extended across to Grave Peak, 15 miles distant from the main divide.

SOUTH FORK OF BITTERROOT RIVER.

TOPOGRAPHY.

At the junction of the East and South forks of Bitterroot River the valley is still an open one, with bottom lands 1 mile wide and broad gravel terraces, the latter continuing for several miles up along the easterly branch of the stream. Broad and partly timbered ridges ascend with comparatively easy slope from the East Fork, their summits forming a nearly level sky-line 2,000 or 3,000 feet above the valley. A low granite ridge projects from the Bitterrroot foothills, connecting with the mountains surrounding the East Fork, and across this ridge the South Fork breaks in a narrow canyon, suggesting that a former valley, nearer to the Bitterroot Range, has been filled by morainal débris and a new trench excavated through the granite ridge in post-Glacial time. For a distance of 15 miles above this canyon the South Fork flows in a narrow valley which, however, opens up a little immediately south of the canyon through the granitic ridge mentioned. The bottom, though narrow, is flat, and occasionally fragments of a low terrace appear above the stream. Where the Nez Perce trail leaves the South Fork the West Fork Valley branches and forms a wide, open depression. Above the West Fork the main branch continues narrow, with flat bottom and sides rising steeply for a few hundred feet up to a sloping bench, from which heavily forested broad ridges run up to a similar main divide very different from the narrow arêtes and pinnacles of the Bitterroot ridges. These conditions continue for several miles above the West Fork to near Hughes Creek (elevation, 5,000 feet), where the valley opens to a width of half a mile and is surrounded by bluffs of rock 1,000 feet high. Above this creek the Bitterroot River splits in many branches and the rounded forest-covered ridges of the Salmon River divide are soon reached. The highest elevation of this is found at Blue Nose Mountain, which attains 8,300 feet, but the average height of the dividing ridge is considerably less.

Unio shells. According to Mr. W. H. Weed much rhyolite is also seen along the East Fork of Bitterroot River.

While there is no direct proof of the age of the rhyolite, it is probable that, like nearly all of that rock in Montana, it is of middle Tertiary or Miocene age. Its topographic extent is perhaps the most interesting feature, as it clearly proves that the configuration, depth of canyon, etc., in the upper South Fork were about the same as at the present time. As far as this fork is concerned, subsequent events have consisted rather of repeated fillings and retrenchings of the pre-Miocene excavations than of any important deepening of the channel.

QUATERNARY.

The Quaternary deposits along the South Fork of the Bitterroot are limited to the bottom lands and terraces along the river. Though the bottom lands are narrow and of slight extent, they persistently follow the river, indicating a recent damming, which deprived the river of its full erosive power. In few places the water flows over exposed bed rock. Above these alluvial areas are several terraces, preserved in fragments, indicating that at a comparatively recent date gravels filled the canyon to a depth of over 500 feet. The analogy with Lolo Fork (p. 38) is apparent. In the lower South Fork one direct cause for the accumulation of gravels above is found in the fact that during the Glacial epoch the moraines of Trapper and Boulder creeks produced effectual dams of considerable height. Whether this is sufficient or whether the uniform filling of Lolo, the Bitterroot Valley, and the South Fork to a height of 400 to 500 feet above the present water level was due to more universal causes acting farther down on the Clark Fork of the Columbia can not be regarded as fully settled. The erosion which followed the maximum of deposition was clearly of active character and is responsible for the steep bluffs which now in many cases skirt the river.

As stated above, three terraces, 30, 100, and 200 feet above the river, form the broad valley at the junction of the two forks. Immediately above this the South Fork emerges from a narrow canyon extending for a few miles and then opening up a little at intervals. A low terrace, 20 feet above the river, follows closely, and in places are remnants of another 200 feet above the stream. At the mouth of West Fork the lower terrace is well developed, and another of gravel and silt appears on the west side 200 feet above the river. Near the mouth of Blue Joint Creek gravel was noted from 500 to 550 feet above the river. At the mouth of Hughes Creek gravel bars are found at 20, 50, 200, and 500 feet above the river, thus reaching up to elevations of 5,660 feet.

CLEARWATER MOUNTAINS.

TOPOGRAPHY.

As defined above (p. 13) the Clearwater Mountains form a roughly rectangular area 70 miles wide and 100 miles long (from north to south) bounded on the south by Salmon River, on the north by the North Fork of the Clearwater, on the east by the Bitterroot Range, and on the west by the Columbia lava plateau which begins a short distance east of the South Fork and the main Clearwater River. This broad area of about 7,000 square miles can not be regarded as a mountain range due to orographic forces acting along certain lines, but must be considered as due to a continental uplift acting evenly over the whole area. It is, briefly, an elevated plateau, of approximately uniform height, now so deeply dissected by such an intricate system of canyons that at first glance it has almost lost its once doubtless prominent plateau features.

RIDGES.

Three primary divides extend westward across the whole width of the Clearwater Mountains from the backbone of the Bitterroot Range. The most northerly is the ridge between the North Fork and the Lochsa Fork. Immediately west of the broad, low depression of Lolo Pass this divide rises to elevations of from 6,000 to 7,000 feet, and its bleak summits of white granite with scattered dark groups of firs extend for 50 miles west-southwest, maintaining about the same height. From near Rocky Ridge it slopes gently with many low spurs, within a distance of 18 miles, down to the basalt plateaus of Weippe, which are situated about 3,000 feet above sea level.

The Lochsa-Selway divide, of about the same length, is more broken and irregular; and its peaks are also higher. From the Bitterroot Range it forms a succession of points and high ridges, such as Grave Peak (elevation 8,287 feet), Diablo Peak (elevation 7,531 feet), and near the western end of the ridge, The Crags (elevation 7,923 feet). Ten miles west from the bare granite points of the Crags, the thickly forested ridge descends abruptly to the junction of Lochsa and Selway forks. Toward its head the Selway Fork splits in a great number of branches, separated by complicated ridge systems. Many of these head toward the Salmon River divide, which is a high ridge with many and sharp curves due to tributaries cutting into it from north and south.

The Salmon River divide begins a few miles northwest of Blue Nose Peak (at the head of the South Fork of the Bitterroot) and continues westward for fully 80 miles as a high, broad ridge, sparsely timbered and sometimes with swampy meadows surmounted by a few points exceeding 8,000 feet in elevation. Above rarely afford space for a trail along the water line. Only along its lowest course from Stuart to Lewiston is the Clearwater lined at intervals with small strips of bottom lands. For 60 or 70 miles above Lewiston it has cut a trench 1,000 to 2,000 feet deep, with precipitous slopes, through the horizontal beds of the Columbia River lava; beyond this limit begin the Clearwater Mountains, and in this province the canyons are less precipitous but far deeper, 4,000 feet being a common vertical distance between the summit of the ridges and the bed of the stream. The slopes are fairly gentle for some distance from the summits, but become much steeper farther down toward the bottom. Forty miles above Lewiston the Clearwater receives the North Fork, which drains a large territory, its headwaters reaching the Montana-Idaho boundary line. This fork lies almost entirely outside the territory covered by this reconnaissance. Forty miles farther up the river again divides; the Middle Fork continues 25 miles due east in a deep canyon cut through the westerly ramparts of the Clearwater Mountains and then forks again. The northerly branch, Lochsa Fork, heads near Lolo Pass and flows through a canyon 4,000 feet deep, receiving few tributaries from either side. The southerly branch, called the Selway Fork, drains the larger part of the western slope of the Bitterroot Mountains and splits up in a maze of branching and winding streams. The South Fork, finally, which is considerably smaller, and has a less deeply trenched canyon, heads near the Salmon River divide, first flowing in a westerly direction, changing at Mount Idaho to a northerly course.

The grade of the rivers is by no means excessively great, that of Lochsa and Selway forks varying between 25 and 40 feet per mile through the main part of the mountains. Close to the Bitterroot Mountains the grade becomes much steeper and the branches finally head in the great glacial cirques on the west side of the Bitterroot Range.

A peculiar feature throughout this region is that the rivers receive their largest tributaries from the south and that near their headwaters they have a tendency to bend to the south.

The Salmon River throughout this region flows in a deep canyon without appreciable amounts of bottom lands. This trench is less split up into branches and is even more impressive than that of the Clearwater, its sides being also more precipitous. From Shoup to Freedom, a distance of at least 130 miles, the canyon is from 4,000 to 5,000 feet deep and about 10 miles wide, and has cut through the great uplifts of pre-Tertiary rocks. From Freedom to its mouth the river flows for about 60 miles through a high plateau of Columbia River lava, older rocks being, however, generally exposed in the bottom of its canyon.

Snake River is the main trunk stream of this region, and here forms the boundary of Idaho on one side and Oregon and Washington on the other side.

It first receives the Salmon and, 40 miles farther down, the Clearwater. Throughout this region it flows through the Columbia lava plateau in a deeply incised canyon, usually with steep sides. This canyon "may be divided into two well-defined sections of about equal length. Throughout the southern half of its course the river is in the bottom of a magnificent canyon with deeply sculptured walls 4,000 feet high and about 15 miles wide at the top. The rim rock at the crest of the walls on each side is formed by the edges of a lava sheet which immediately underlies the surface of Craig Mountain and of another similar plateau in Oregon. The northern half of the portion of the canyon referred to is narrow, being perhaps 2 miles wide at the top, and is cut in nearly horizontally bedded lava sheets; the walls, which are so steep that they appear vertical, are about 2,000 feet in height."[a] (Pl. XIII.)

GEOLOGY.

GRANITE.

From all available information granitic rocks of massive structure prevail over the whole extent of the Clearwater Mountains. Gneisses appear only at Pierce, Elk City, Salmon Mountain, and Horse Creek in areas of moderate extent, everywhere shattered and intruded by granite dikes. The Clearwater granite is, in general, a light-gray granular rock containing biotite and some muscovite, quartz, orthoclase, and a large quantity of oligoclase, indicating a relationship to the quartz-monzonites. The grain varies from coarse to medium, and larger orthoclase crystals up to 1 inch in diameter are sometimes present. The quantity of soda-lime feldspar is also variable, and in a few places the rock is a normal granite. Pegmatitic dikes are not very common except in some portions of the gneissoid areas. The structure is usually massive, though an incipient schistosity is noted in some places, being especially frequent in dikes contained in the gneiss.

From Lolo Pass, St. Marys Peak, and the summits at the head of Mill Creek the white outcrops of vast granite areas are seen far to the west. The Grave Peak complex and the whole of Lolo Ridge are probably of granitic character. The rock from Sherman Peak, on the western slopes, is a normal rock with much biotite and a little muscovite, orthoclase, and microperthite and a large quantity of oligoclase. A few smaller feldspar prisms are labradorite. Near Pierce, on Oro Fino Creek, the granite is slightly schistose and dioritic modifications occur near the contact of the true gneisses, beginning a short distance below the town.

The Crags form the last high projecting point on the Lochsa-Selway divide. This rock, like the one just described, is closely allied to the quartz-monzonites.

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[a] Russell, I. C., Water-Sup. and Irr. Paper No. 53, U. S. Geol. Survey, 1903, p. 63.

Orthoclase and perthite are present in smaller quantity, but there is much oligoclase; biotite occurs in small foils.

The complex of Bilk Mountain was not visited, but from appearance, reports, and photographs by Mr. Lippincott granite is here the prevailing if not the exclusively occurring rock. (Pl. XI, *B.*)

At Lost Horse Pass, described above (p. 44), the granite shows evidence of schistose structure and is cut by many joint planes. Granitic rocks also prevail for a long distance west of that pass.

On the Salmon River divide granite begins on Horse Creek, and is cut by many dikes of granitic and dioritic porphyries. The rock is here of the normal Bitterroot type but varies in grain. West of the gneiss area of Salmon Mountain light-gray biotite granite prevails again, but contains many sharply defined inclusions of gneiss and occasional dikes of granite-porphyry. On the ridge east of Little Salmon River the granite has a slightly gneissoid structure. From this point to Ryans Meadows on the Red River, where the wagon road to Elk City begins, granite prevails. A specimen 4 miles west of Little Salmon Meadows is a coarse biotite-granite, orthoclase prevailing over the plagioclase, which seems to be an andesine. In the scant outcrops inclusions of micaceous and often contorted gneiss are common, indicating, perhaps, the vicinity of a larger gneiss area. Many of these gneiss fragments are injected in the small pegmatitic dikes parallel to the schistosity. After the large gneiss area of Elk City has been traversed the road leads down from Summit House to Harpster on the Clearwater. Granite adjoins the gneiss here and occupies the western slope toward the river down to an elevation of 3,800 feet, where the granite borders with intrusive contact against black slates and limestone of probably Triassic age (p. 73).

Granite occupies large areas again on the head of Crooked River. A specimen from the Homestake mine is a coarse biotite-muscovite rock, containing abundant microcline and a small amount of oligoclase. It is clearly a typical granite, comparatively rare in this region.

On the other hand, at Buffalo Hump the light-gray granular rock contains very little muscovite, very abundant oligoclase, and probably also andesine; it is evidently a quartz-monzonite. The Florence granite is similar, while at Warren (south of Salmon River) there is much muscovite and a smaller quantity of soda-lime feldspar.

GNEISS.

The gneiss areas lie embedded at various places in the granite, dikes of which are abundant in the schistose rock. Ordinarily it is a biotite-microcline-gneiss which evidently is derived from a granite; crushing and folding on a small scale are very frequent. The dip, usually moderate, is characteristically variable.

Beginning on the north a series of coarse micaceous and hornblendic banded gneisses appear on Oro Fino Creek just below the mining camp of Pierce (p. 102). Their strike is N. 70° W., the dip being nearly vertical. South of Pierce on Musselshell Creek and thence up to Sherman Peak granite prevails, but smaller areas of gneissoid rocks, probably inclusions, are encountered in places.

South of this begins the greatest gneiss area of this region, extending 40 miles long and 20 miles wide across the Middle and South forks of the Clearwater. Most common is an often crumpled biotite-microcline-gneiss with characteristically variable strike and dip, the latter from 20° to 90°. Coming from the east on the Nez Perce trail this gneiss is first met at Ryans Meadows and continues to Elk City, 15 miles distant. It is coarse, rich in mica, and often crumpled perpendicularly to the strike. The gneissoid structure is chiefly caused by the parallel arrangement of the mica foils, to less extent by the elongation of other constituents. Microscopically it consists of much microcline, orthoclase, and quartz, with less amount of plagioclase of medium acidity. There is further biotite with some hornblende, titanite, and epidote, the latter seemingly primary. Sometimes the mica foils curve around the white constituents, giving the rock an ocellar structure. It is well exposed in the bed rock of American Hill placer mine (p. 93) and here contains bands of fine-grained very micaceous rock and many narrow pegmatite dikes parallel to the schistosity. Dikes and gneiss are greatly contorted and crumpled. At Buffalo Hill placer mine the bed rock is similar gneiss but is cut in all directions by granite dikes. On Crooked River gneiss with micaceous streaks continues to a point 2 miles below the Badger mill, where it is replaced by intrusive reddish granite. Similar micaceous gneisses prevail between Elk City and Newsome and continue, cut by granite dikes, to a point 2 miles west of Mountain House, on the main road, where it is cut out by intrusive granite. Three and one-half miles west of the same place a narrow wedge of gneiss crosses the road, but granite again sets in and continues to near the foot of the grade to the Clearwater River.

The Middle Fork cuts across this gneiss area from Stuart eastward to beyond the Lochsa and Selway forks. Six miles above Stuart granitic gneiss begins; 8½ miles above are greenish schists striking N. 30° W. and dipping 70° WSW. Then follows micaceous gneiss up to the forks of the river. The point of the ridge between these is of gneiss, but 6 miles west of the Crags the trail crosses into the granite which forms the Crags. Near the contract the gneiss is cut by dikes of granite and pegmatite.

East of the Elk City gneiss area the granite contains many gneissoid inclusions. No large areas are, however, encountered until the great reef of Salmon Mountain is crossed. This consists chiefly of gneiss, extending probably all the way from Caseknife Mountain on the edge of the Salmon River Canyon north to McGruder Mountain. The whole mass is a banded and contorted micaceous gneiss, striking northeast and dipping steeply northwest. A specimen from the top of Caseknife Mountain is a gray and medium-grained gneiss consisting of allotriomorphic quartz, orthoclase and andesine with many foils of dark-brown biotite. Granitic injections of aplite, hornblendic granite, granite-porphyry, etc., are very extensive.

Good exposures were seen by Mr. Stose in the glaciated gulch leading up to Caseknife Mountain from Salmon River on the southeast. Numerous slipping planes suggest movement along the schistosity. In places the gneiss is much folded, quartz veins crossing the schistosity partaking in this movement. Intrusive granite dikes are common and have been made gneissoid parallel to the schistosity.

On the ridge eastward between Salmon Mountain and Horse Creek granite prevails but contains very sharply defined and broken shattered fragments of gneiss.

The most easterly area of gneiss begins on Horse Creek and extends up to the divide between Salmon and Bitterroot rivers, including the mining district of Mineral Hill (p. 90). This area which may possibly connect with that of Salmon Mountain along the deep canyon of Salmon River, borders against intrusive granite on the west, and probably underlies the sedimentary series of the head of the South Fork of the Bitterroot on the east. The gneiss is often coarse and dark gray and shows ocellar structure due to the curving bands of biotite. It consists of biotite, quartz, much microcline, and a small amount of plagioclase. Many bands are highly micaceous and sometimes contorted. The strike of this gneiss at the Horse Creek mines is north and south; the dip 40° E. The poor outcrops rarely permit good determinations, and a secondary cleavage often makes it difficult to find the true schistosity. Many dikes of granite-porphyry and granite cut this series.

SEDIMENTARY ROCKS.

Only few and small areas of sedimentary rocks have thus far been noted in the Clearwater Mountains, granite prevailing everywhere with smaller areas of gneiss. The probably pre-Cambrian areas of Lolo Fork and South Fork of Bitterroot River apparently do not enter the watershed of the Clearwater River, though continuing close up to its limits. On the western side a small area of dark-gray, fine-grained quartzites is found on Relief Creek between Crooked River and Red River, south of Elk City. Nothing is known as to their relations with the surrounding gneisses. Pebbles of this rock are very common at the Buffalo Hill hydraulic mine on American River (see p. 94). The only other sedimentary rocks encountered form irregular inclusions in the granite of Buffalo Hump (see p. 98). They are slates, quartzites, and limestones of unknown age, shattered by granitic dikes and greatly contact metamorphosed to mica-schists, hornfels, and garnetiferous products. Many of these rocks contain microscopic tourmaline.

TERTIARY GRAVELS.

The great flows of the Columbia River lava dammed the old drainage ways to present elevation of about 3,000 or 3,200 feet. The natural result was heavy accumulations of gravels in the lower reaches of the Clearwater streams. Remaining benches of such gravels are beautifully developed in the Elk City mining district (p. 91), where the highest of these attains an elevation of 4,500 feet. Similar conditions existed, closer to the valley, at Pierce, where the highest remaining gravel benches reach elevation of 3,300 to 3,500 feet (p. 102). Remains of gravels are also found on the ridge between Lolo and Musselshell creeks at an elevation of 3,700 feet.

GLACIATION.

The large confluent ice sheet which once covered the whole of the Bitterroot Range has been described in some detail on a previous page (p. 51).

Within the Clearwater Mountains no evidence of such general and widespread glaciation is found, due of course to the fact that the mountains rarely attain an elevation equal to that of the Bitterroots. The glaciation in the Clearwater Mountains is confined to a few isolated localities, and evidences of its existence appear wherever any considerable area of country exceeds 8,000 feet in elevation.

Beginning on the north the first center of glaciation is met at Rhodes Peak on the Lolo Ridge, from which doubtless small glaciers extended in several directions. Going west another local center from which small glaciers radiated appears at Bald Mountain and Castle Butte. Finally, a few miles farther west on the slopes of Rocky Ridge three or four smaller glaciers appear to have descended the streams leading up to that peak.

The ridge between Lochsa and Selway forks of the Clearwater is rougher and higher than the Lolo Ridge, and Grave Peak was evidently the center of an extensive glaciation, the ice streams descending in all directions from it. It is probable that this ice field was connected by way of Diablo Peak with the main ice-covered area of the Bitterroot Mountains. The glacial lakes near Grave Peak are shown on Pl. XII.

Still farther west the Crags near the end of the ridge rise to an elevation of over 7,900 feet. Small glaciers doubtless descended from their summits.

On the southern divide between Salmon River and Selway Fork the effects of glaciation are only prominent around two centers. The first one is Salmon Mountain reaching 8,881 feet. From the broad shoulders of this mountain wide glacial cirques descend in several directions. The glaciated area here probably covered 20 or 30 square miles. The divide from this point eastward to the head of the South Fork of the Bitterroot is very high and local glaciers may well have existed in some places.

of the rivers stands in some causal connection with the bold scarp of the Uniontown plateau which all along follows their north side; the general elevation of the latter plateau is 2,500 to 3,000 feet and the steep slope carries it down 1,500 to 2,000 feet to river level.

GEOLOGY.

PRE-TERTIARY FORMATIONS.

An examination of the many deeply cut canyons within the province of the Columbia River lava soon reveals the fact that the underlying surface of older pre-Miocene rocks is extremely uneven and that the bottoms of the main streams before the time of the lava flows were at a lower level than they are at present. Thus the old rocks are irregularly exposed in many canyons and again at other places west of the main slope of the Clearwater Mountains where they are partly or wholly surrounded by the volcanic flows which rise above the general level of their surface.[a]

The series of rocks exposed below the lava is of a very complex character and consists of slates, sandstones, limestones, greenstone-schists, gneiss, diorite, and granite, the detached exposures making the study difficult. It is pretty clear, however, that two or three systems of bedded rocks are present. The first and oldest is chiefly exposed on the North Fork and at Oro Fino and consists of true gneisses and mica-schists, sometimes with intercalated limestone; it bears the marks of extensive regional metamorphism and is probably very old, possibly pre-Cambrian, and should be classed with the gneisses of Pierce and Elk City. The second and younger series is exposed on the Cottonwood Buttes and in the great canyon of the Snake; it is distinctly sedimentary, containing limestone, sandstone, and black slates, much disturbed but of imperfectly known structure, and associated with it are large masses of greenstones partly schistose and tuffaceous.

A third division consists of the also distinctly sedimentary rocks of Salmon River Canyon, Mount Idaho, and Harpster, which continue up to this point from the Seven Devils with persistent northeasterly strike. This division, which may be identical in age with the second series, is believed to be of Mesozoic-Triassic age. Granite and diorite, forming a spur of the great area of this kind of the Clearwater Mountains, has been intruded on a large scale into these three divisions of sediments. A bay of these rocks extends from Pierce, crossing the Clearwater near Kamiah and Greers Ferry, to eastern part of the Cottonwood Buttes, probably reaching the canyon of the Salmon west of Grangeville.

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[a] For these projecting points of more ancient rocks, islands as it were in the lava floods, Professor Russell has proposed the name of "Steptoes," from a butte of that name north of the area here considered.

Of all the main underlying rock formations this is doubtless the youngest. An approximately correct map of the exposures below the lava may be seen on Pl. I.

Beginning with Snake River, the first exposure of pre-Neocene rocks is noted in the basalt canyon of the Snake River, 26 miles below Lewiston. It is a coarse light-gray gneiss, apparently a sheared granite with large pressed aggregate of orthoclase and quartz, surrounded by flaky films of biotite and hornblende. The exposure is one-half mile long and rises 250 feet above the river. On the Clearwater no exposures of old rocks are seen until 25 miles above Lewiston and 3 miles below Contact, from which place the exposures continue for 8 miles until a point above Oro Fino. In Bedrock Creek and Big Canyon, quartzites and greenstone-schists are exposed, seemingly identical with the Cottonwood Butte series and having a strike of N. 25° W., the dip being 30° E.

At the mouth of the North Fork, Professor Russell[a] found diorite, gneiss, and micaceous garnetiferous schists striking a little west of north and dipping 70° to 80° E. One and one-half miles above the mouth of North Fork the rock is a fine-grained gneiss with bands of whitish quartzite. The strike is N. 70° W., the dip 65° NNE. A short distance above the town of Oro Fino the rocks are micaceous quartzite and mica-schists, containing a coarsely crystalline limestone in well-defined beds 120 feet wide, which may be followed for 1½ miles southward, where it is narrow, and one-fourth mile northward. The strike is N. 25° E., and the dip 78° ESE. Two and one-half miles above Oro Fino the micaceous quartzites and mica-schists strike N. 55° W., dipping steeply southwest. Near the mouth of Ford Creek basalt covers the bottom of the canyon. South of Ford Creek, about Greers Ferry and the mouth of Lolo Creek, the prevailing rock is a massive granite or diorite, some of it at Greers Ferry being a very beautiful coarse pegmatite, consisting of plagioclase and hornblende. A few miles above Kamiah the granite disappears below the basalt, which now for 10 miles or until a few miles below Harpster, forms the bed of the river.

Small bed-rock exposures occur on the top of the plateau near Fletcher, on the head of Big Canyon, and on Mission Creek, where limestone has been observed by Professor Russell.[b]

The Cottonwood Buttes are, as stated above, a series of pine-clad hills projecting somewhat over 1,000 feet above the lava plateau of Camas Prairie. The western and highest part consists of prevailing greenstone-schists, alternating with massive greenstones and smaller areas of partly tuffaceous clay slate and quartzitic slates, the latter fairly being well exposed on the road from Cottonof this formation except the deep, fertile, dark-brown soil, to which it easily disintegrates.

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[a] Water-Sup. and Irr. Paper No. 53, U. S. Geol. Survey, 1903, p. 24.

[b] Water-Sup. and Irr. Paper No. 54, U. S. Geol. Survey, 1903, p. 120. Analyses are here given of limestones from Snake River, Mission Creek, and Oro Fino. All are practically pure carbonate of calcium, the last named only containing 3 per cent magnesia.

Along the walls of the many abrupt canyons which trench the formation its composition is beautifully and clearly revealed. The cliffs and slopes, of somber dark-brown color, present a great number of horizontal, long, and persistent lines delimiting the individual flows and due to their varying resisting power toward erosion. Each flow is from 25 to 150 feet thick, the upper and sometimes also the lower part of each being more scoriaceous than the central part. Throughout the prevailing rock is a basalt,[a] though varying much, for while some flows are very glassy others are almost granular and have a diabasic structure. These differences are no doubt due to differing conditions of cooling. A columnar structure, due to vertical contraction joints, is observed in places.

In fresh specimens the basalt is nearly black, sometimes vesicular, more frequently massive. Typical specimens from the Clearwater Canyon, 4 miles below Contact and from the mouth of Potlatch Creek, are massive, black rocks of fine grain, and containing prisms of labradorite up to one-half inch long. In thin section they prove to be olivine-basalt of diabasic granular structure, but also containing between the grains some dark-brown glass. Porphyritic labradorite crystals are on the whole very common in many flows. The basalts from the plateau of the Columbia River lava near the Seven Devils, Eagle Creek Range, and Boise are entirely similar.

The only analysis of the Columbia River lava thus far available is a partial one, by Prof. Geo. P. Merrill, of a basalt from Walla Walla, and runs as follows:[b]

Analysis of basalt from Walla Walla, Wash.

SiO_2	47.35
Al_2O_3 Fe_2O_3	34.38
MgO	4.43
CaO	8.27
Na_2O	2.55
K_2O	1.33
Loss on ignition	.95
	99.26

The persistence in petrographic characters over large areas is noteworthy.

The age of the basalt flows would seem to be Miocene from the paleo-botanical evidence thus far available. (See p. 24.) Possibly Eocene eruptions make up a part of the formations hitherto grouped under the name of Columbia River lava.

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[a] Russell, I. C., and Diller, J. S., Water-Sup. and Irr. Paper No. 4, 1897, p. 43. Lindgren, W., Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 90-93; Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 592-593; Geologic Atlas U. S., folio No. 45, Boise, Idaho.

[b] Water-Sup. and Irr. Paper No. 53, U. S. Geol. Survey, 1903, p. 44.

terrane it may of course be broken and faulted by orogenic forces. Comparatively little such folding or faulting has taken place, indicating a general absence of tangential compressive stresses. This seems to hold good, not only of the lava plateau, but also of the higher and older largely granitic plateau of the Coeur d'Alene, Clearwater, and Salmon River Mountains. The whole of central Idaho should perhaps be regarded as a rigid crust block, but little folded or faulted since Mesozoic time.

Some disturbances of the Columbia River lava have, however, occurred in this region. Along the foot of the Clearwater Mountains the top of the lava flows is generally found at an elevation of 3,000 feet above the sea. Practically the same elevations obtain on the Camas and Kamiah prairies and on the Uniontown Plateau, and this level may be regarded as the surface of the sea of molten rock. Fifteen hundred feet lower than the general level is the Lewiston Plateau, bordered on the north by the Clearwater escarpment. Up to 1,500 feet higher than this level, is Craig Mountain, a long, broad lava swell, extending in a west-northwest direction between the Snake and the Clearwater. (Pl. I.) Both of these features Professor Russell regards as monoclinal folds.[a] The Lewiston Plateau is part of a synclinal trough, bordered on the north by the monoclinal fold of the Clearwater escarpment (Pl. XIV). Craig Mountain is a gentle anticline separating the Lewiston Plateau from Camas Prairie. (Pl. I.)

Epeirogenic disturbances.—In a previous paragraph it has been shown that the combined ridge lines of the Clearwater Mountains (and also of part at least of the Salmon River Mountains south of the stream of the same name) would form a broad plateau surface, with an average elevation of about 7,000 feet. In places this plateau was depressed to 6,000 feet, while in other places irregular groups of hills rose to 1,000 feet above the average level. A slight westward slope probably existed and was the determining factor in the general plan of the rivers. This surface was evidently a surface of erosion, an old topography reduced from still older mountain systems, and lifted, like the rest of the great Idaho mountain mass, by epeirogenic processes long before the Miocene epoch to the position of a high plateau in which rejuvenated rivers could begin new and active processes of canyon cutting. The rather sudden descent from this old plateau to the later one of the Miocene lava is noteworthy. It can scarcely be due to erosion, but is rather due to deformation of the crust as suggested in the case of the similar steep descent of the plateau of the Boise Mountains to the lower valley of the Snake River.[b] The general character of this plateau between Florence and Buffalo Hump, and its contrast against the deep canyon of the Salmon River, is clearly shown on Pl. IX of the Twentieth Annual Report of the United States Geological Survey, pt. 3.

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[a] Water-Sup. and Irr. Paper No. 53, U. S. Geol. Survey, 1903, pp. 54–61.

[b] Geologic Atlas U. S., folio No. 45, Boise, Idaho.

COEUR D'ALENE MOUNTAINS.

The geology of these mountains is practically unknown, and this may be the excuse for publishing the following brief notes taken during 1899, on a trip from Lewiston to Spokane and thence across to Montana by way of Mullan Pass. A short stay was made at the Coeur d'Alene mines, and such notes regarding these important lead deposits as are available will be found on page 108.

Going north from Lewiston on a branch of the Northern Pacific Railway one soon ascends the Uniontown Plateau, which has an elevation of 2,500 feet, and the route continues for 50 miles northward just west of the Washington-Idaho line, over a rolling open country of Columbia River lava, well cultivated and forming a part of the rich wheat lands of the "Palouse country." Spurs of older rocks project from the Coeur d'Alene Mountains and points of the same in places reach up above the general surface of the lava plateau. Of the former kind are the Cedar Mountains, near Moscow, Idaho, consisting of quartzite and granite, and the Tekoa Spur from the Moose Creek Mountains, which consists of slate. Of the latter kind are several quartzite points north of Pullman, as well as the Steptoe and Kamiack buttes described by Russell.[a] Fifteen miles from Spokane the road crosses an area of very decomposed granite, locally used for the manufacture of fire bricks, and descends to the Spokane River, which near Spokane is flanked by basalt flows. These are underlain by fluviatile or lacustrine clays, which are probably younger than the Columbia River lava.

From Tekoa a branch road runs up to Coeur d'Alene Lake and thence eastward across Mullan Pass into Montana. Along this line the formations seen are as follows:

After crossing slates and quartzites, a spur from the small complex known as the Moose Creek Mountain, the basalt begins again near Coeur d'Alene Lake and rises to bluffs forming a plateau 500 feet above the water (elevation about 2,500 feet). The Columbia River lava continues up the Coeur d'Alene River a few miles east of the lake, and then begins a sedimentary series of great thickness, which continues with west-northwest or northwest strike almost uninterruptedly to Missoula, Mont. The mountains consist of a maze of steep, narrow ridges, 1,000 to 3,000 feet high, the level crest lines of which have an elevation of from 5,000 to 6,500 feet. This region should be regarded as a very extensively dissected plateau. At first banded quartzitic slates prevail. North of Wardner the prevailing strike of the slates is N. 62° W. and the dip about 50° NNE. At Wardner the rock is a heavy-bedded gray quartzite, of medium grain; the bedding planes strike N. 70° W. with a dip of 60° SSW. Quartzite continues up to Burke and

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[a] Water-Sup. and Irr. Paper No. 34, U. S. Geol. Survey, 1900.

Along the road from Mount Idaho to Florence, a few miles south of the former town, granite and some schists are exposed below the lava contact.

East of Mount Idaho, in the canyon of the South Fork of the Clearwater occurs a series of sediments which seem to be the direct continuation of those of the Salmon River Canyon. Mount Idaho is situated on the basaltic plateau, but in the canyon immediately east of it and 1,500 feet lower greenstone-schists, with bands of clay slate having a northeasterly strike, prevail. They are well exposed between the Dewey mine (p. 105) and Hinckley's ranch. A few injected granite dikes were observed in the schists. On the steeply rising hills east of the river at Hinckley's greenstone-schists first prevail, but 1,600 feet above the stream a strong and persistent belt of crystalline limestone is crossed, adjoined on the east by heavy masses of black and gray banded quartzitic slates.

At Harpster, 10 miles farther down the South Fork, dark-green, medium-grained diorite is exposed in the bottom of the canyon below the lava, and continues for a few miles beyond that place until the lava dips below the river level. Prospectors affirmed that the diorite continues for 4 miles above the Harpster bridge. Above this there is said to be an alternation of limestone, slate, and greenstone.

The most northerly exposure of this important northeasterly striking series is found on the road 5 miles east of Harpster. At an elevation of 3,850 feet, at the foot of a long grade descending over granite from Summit House and near the beginning of the lava plateau, appear outcrops of finely laminated clay slates striking N. 60° E. and containing well-defined dikes of granite. Two miles south of this point Mr. Johnson found a bed of pure white crystalline limestone 60 feet thick associated with decomposed greenish slates. This limestone would seem to be in the northeasterly continuation of the bed noted east of Hinckley's ranch; it had been utilized for quicklime, as indicated by a kiln built at the outcrop.

Northeast of this point the sedimentary series is replaced by an apparently far older gneissoid series. The similarity of this whole northeasterly striking series from Huntington to the South Fork of the Clearwater and the definite identification at the Seven Devils warrant the belief that it is throughout, largely at least, of Triassic age.

BASALT FLOWS.

Topographically and geologically basalt is the most important component rock of the high plateau spread out at the foot of the Clearwater Mountains. As already indicated, the plateau is chiefly built up of a great number of horizontal basaltic flows, to which Professor Russell has given the formation name of the Columbia River lava. On the rolling surfaces of the high prairies little is seen of this formation except the deep, fertile, dark-brown soil, to which it easily disintegrates.

Along the walls of the many abrupt canyons which trench the formation its composition is beautifully and clearly revealed. The cliffs and slopes, of somber dark-brown color, present a great number of horizontal, long, and persistent lines delimiting the individual flows and due to their varying resisting power toward erosion. Each flow is from 25 to 150 feet thick, the upper and sometimes also the lower part of each being more scoriaceous than the central part. Throughout the prevailing rock is a basalt,[a] though varying much, for while some flows are very glassy others are almost granular and have a diabasic structure. These differences are no doubt due to differing conditions of cooling. A columnar structure, due to vertical contraction joints, is observed in places.

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The persistence in petrographic characters over large areas is noteworthy.

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[b] Water-Sup. and Irr. Paper No. 53, U. S. Geol. Survey, 1903, p. 44.

Intercalated between the basalt flows are occasionally found thin beds of white volcanic dust of rhyolitic character. Professor Russell mentions such occurrences from each side of Potlatch Canyon; beneath the Candle Rocks, on the left bank of Snake River below Lewiston; near Swallow Rock, between Clarkston and Asotin; also on Asotin and Captain John Creek in the canyon of the Snake above Lewiston.[a]

Waterlaid beds, consisting of clays and sands swept down from the surrounding mountains, occur in some places between the lava flows. Basaltic tuffs are practically absent. Professor Russell states that on Small's ranch, on the Lewiston Plateau, the drill encountered 60 feet of sand and 90 to 100 feet of clay below 210 feet of basalt, these sediments being again underlain by basalt. These sedimentary, intercalated beds can be traced over a large extent of country in the northern and western portions of Nez Perce County and adjacent portions of Washington and Oregon. They probably extend to the foothills of the Bitterroot Mountains, but as there are other similar layers in that region they have not been identified east of Craig Mountain.[b] At Cottonwood, on the Camas Prairie, gravel 56 feet deep has been penetrated below a surface sheet of 60 to 70 feet of basalt.

Along the canyon of the Clearwater River, from Stuart to Peck, there are indications of a thick sheet of sandstone and allied rocks at an elevation of about 800 feet below the general surface of the plateau. The true relations are often obscured by landslides. The same, or a similar complex, 200–300 feet thick, is shown throughout the length of Oro Fino Creek from its mouth to near Pierce along the walls of the canyon. These beds begin about 750 feet below the surface of the plateau, as along the Clearwater Canyon landslides are very common. Again, sandstone and carbonaceous slate occur at the same level on Little Canyon Creek, draining a part of the broad plateau south of Oro Fino. Finally, on Potlatch Creek, which joins the Clearwater from the north about 18 miles east of Lewiston, a moderate thickness of sedimentary beds and volcanic dust appears in the basaltic series, 3 miles above the mouth of the canyon.[c] "The Uniontown Plateau is underlain all along its southern border, and apparently throughout practically its entire area, by horizontal sheets of basalt, which include at least one important bed of clay, sand, and gravel, at a depth of about 160 feet below the surface."[d]

STRUCTURE AND PHYSIOGRAPHY OF THE PLATEAU.

Orogenic disturbances.—Like any other series of horizontally deposited beds the Columbia River lava is likely to be deformed into folds, and like any other

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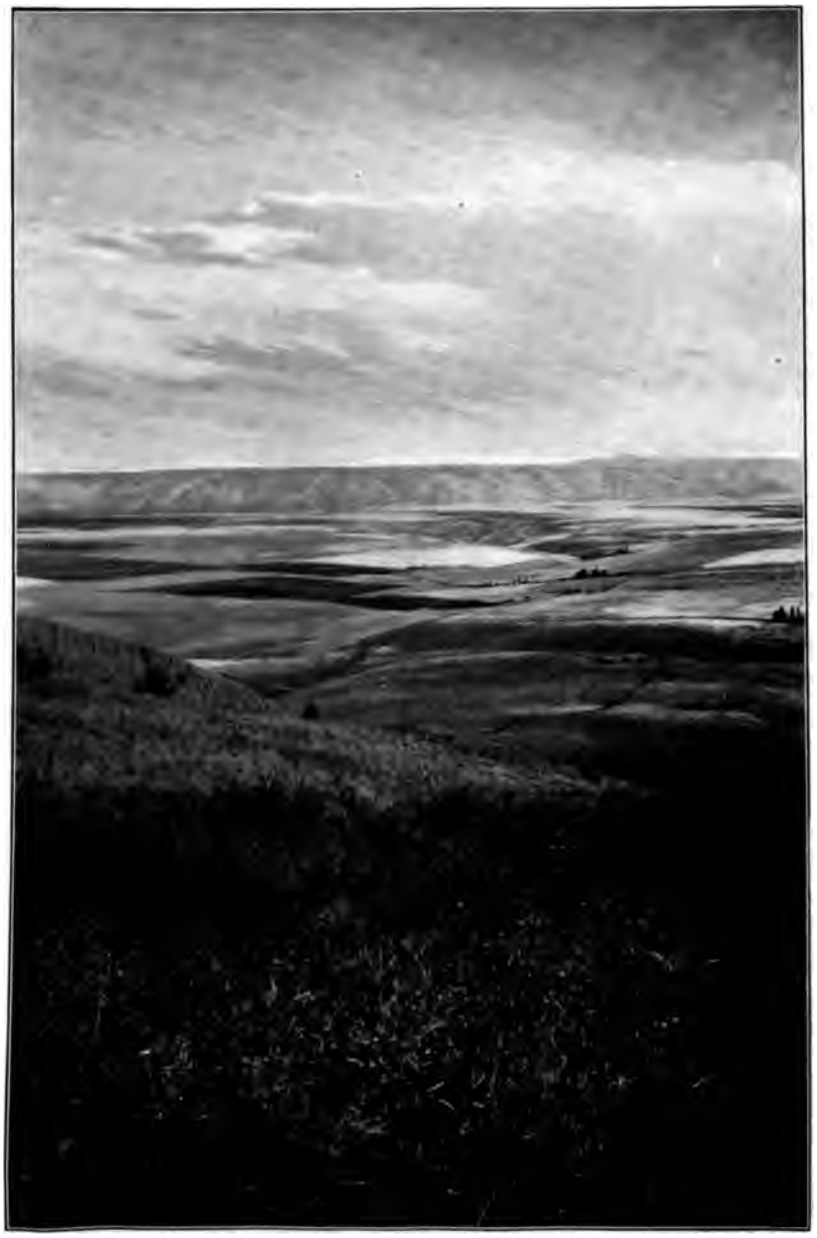
[a] For analysis of this see Water-Sup. and Irr. Paper No. 53, U. S. Geol. Survey, 1903, p. 34.

[b] Water-Sup. and Irr. Paper No. 53, U. S. Geol. Survey, 1903, p. 35.

[c] Ibid., pp. 38–39.

[d] Ibid., p. 57.



LEWISTON PLATEAU, LOOKING NORTH FROM NEAR WAHA.

Clearwater escarpment and Uniontown plateau are seen in the background. (Photograph by I. C. Russell.)

terrane it may of course be broken and faulted by orogenic forces. Comparatively little such folding or faulting has taken place, indicating a general absence of tangential compressive stresses. This seems to hold good, not only of the lava plateau, but also of the higher and older largely granitic plateau of the Coeur d'Alene, Clearwater, and Salmon River Mountains. The whole of central Idaho should perhaps be regarded as a rigid crust block, but little folded or faulted since Mesozoic time.

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[a] Water-Sup. and Irr. Paper No. 53, U. S. Geol. Survey, 1903, pp. 54-61. [b] Geologic Atlas U. S., folio No. 45, Boise, Idaho.

By following the contact line of the Columbia River lava and the older formations of the Clearwater Mountains, it soon becomes evident that the basalt flooded the foothills to an approximate elevation of 3,000 feet; further, that the foothills of the Clearwater Mountains which it covered often had a sharply accentuated topography, and that the lowest points of the main streams of the old pre-Miocene system were considerably lower than the bottom of the drainage of to-day. The present streams of the region, the Clearwater and the Salmon, flow through the mountains in canyons which have a depth of from 3,000 to 5,000 feet. The course of the upper and main parts of these streams could have been but little influenced by the floods of basalt even had they filled their canyons up to a level of 3,000 above the sea. They would in short time have reexcavated their canyons in the lava covering the bottom, and the main features of the great canyons would not have been changed. Only the lowest river courses, below a point where the lava flooded the divides of the canyons, would have been different.

We thus come to regard the whole canyon system of the main fork of the Salmon above Freedom and the similar system of the Clearwater above Stuart and Harpster as a very old one, laid out as a constructive drainage on the slightly westward sloping plateau of the Clearwater Mountains. Its canyons were excavated almost to their present depth in Miocene time, before the Columbia River lava had flooded their lower reaches. Probably the grade was somewhat steeper, the post-Miocene erosion having succeeded in gradually reducing their gradient. The present steep slopes of the canyon walls have been retained, and are most emphasized near the stream lines because of the damming of the lower reaches to elevations of 3,000 feet during the Miocene.

Below the point where the lavas covered one or both of the confining ridges of the canyon the new river course would probably leave the direction of the old valley and follow the chance inequalities of the lava plain. A second series of constructive drainage would thus be outlined, and of this kind is the canyon of the Clearwater below Harpster, the canyon of the Salmon below Freedom, and the great canyon of the Snake River in practically its entire course between Huntington, Oreg., and its junction with the Columbia. In the Clearwater River, lava is first encountered in the bottom of the stream a few miles below Harpster. Consulting Pl. I, we may conclude that the Miocene canyon turned westward from this point and continued below Lawyers Canyon. From here it either extended northwesterly below Big Canyon toward Lewiston, or, less probably, followed the depression between Craig Mountain and Cottonwood Butte in a southwesterly direction. Beyond Big Canyon all is covered by basalt, and the direction of the old river is consequently impossible to determine from surface indications. That an important tributary joined this river below the Lewiston Plateau is indicated by the deep depression, bringing lava to the bottom of the Clearwater Canyon between Greers Ferry and Oro Fino.

In a similar way the pre-Miocene trench of the Salmon River must have continued below the lava plateau between the Snake and the Salmon, and probably crossed the present canyon of the Salmon a few miles above its mouth and the Snake River Canyon between Grande Ronde and Waha.

As stated above, the canyon of the Snake River is of Miocene date and differs entirely from the pre-Miocene valley through which the drainage of the great Snake River Valley found its outlet. The relations of lava and bed rock along the course of the Snake River Canyon from Huntington down indicate that this pre-Miocene trench began near Weiser, Idaho, crossed the present canyon about the mouth of Pine Creek, and continued northwesterly between the Seven Devils and the Eagle Creek Range.

Wherever along canyons the contact lines between lavas and older rocks reveal the old topography its accentuated character is prominent. It is thus at Waha, at the mouth of the Grande Ronde, at Freedom, and at Harpster. In the lower reaches of the rivers the old channels were cut deeper down into the bed rock than the present trenches have been enabled to do, although they have been excavated so deep that at present the river at Lewiston is only about 725 feet above the sea. This leads us to the conclusion that the region of the Columbia River lava along the mountains of Idaho has been depressed, and that it is a field of subsidence of epeirogenic character. This hypothesis I first formulated in a report dealing with the general geology of south-central Idaho[a] and repeated it in a later report on the Blue Mountains of Oregon.[b] Professor Russell has also arrived at the same conclusion.[c]

The problem would be less difficult if the surface of the lava everywhere approximately followed the 3,000-foot contour, as it mostly does along the foot of the Clearwater Mountains, but such is not always the case. On Mount Idaho and on the plateau between the Salmon and the Snake the basalt flows rise to elevations of 4,000 and 5,000 feet. Near the Seven Devils and the Eagle Creek Range they even attain 6,000 and 7,000 feet. Professor Russell[c] reasons that because the lava sheet is in places 4,000 feet thick the top sheet must have had at least that elevation above the sea, unless the old land surface was below the level of the sea, which is admittedly improbable. From this it might be expected that, since the lava sheets in eastern Washington and Oregon and adjacent portions of Idaho are still horizontal, the surface of the plateaus thus formed should have an elevation of at least 4,000 feet above the sea. Instead, we find in numerous instances that the general elevation of the plateaus underlain by essentially horizontal lava sheets is between 3,000 and 3,300 feet. This difference between the present elevation of the locally undisturbed plateaus and what is assumed to have been their original position indicates a subsidence of about 1,000 feet, which may have gone on during the time in which the lava was being extruded or may have occurred in part or wholly since the last sheet was spread out. Proceeding on the same lines, Professor Russell concludes that where slightly inclined strata of lava are found which stand high above the general level of 4,000 feet they have been upraised, and vice versa. The above line of reasoning starts with the assumption that the basalt spread out under hydrostatic conditions. This can not be unqualifiedly admitted to be true; for it seems well possible that near the points of eruption the sheets may have been piled up to gently sloping accumulations considerably thicker than elsewhere.

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[a] Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 96.

[b] Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, p. 598.

[c] Water-Sup. and Irr. Paper No. 53, U. S. Geol. Survey, 1901, p. 54.

It is certain, however, that the course of the whole canyon of the Snake River and of the lower canyon of the Salmon River is difficult to explain except on the assumption that they were originally laid out over an approximately level plateau which has been gradually raised simultaneously with the cutting of the canyon, thus giving them the character of antecedent streams. The course of the Snake River Canyon has been established across the high plateaus at present 5,000 to 7,000 feet above the sea, whereas if no uplifts had occurred other directions would seem to have offered a far more natural outlet for the stream.

In conclusion it is believed that the region of the Columbia River lava has suffered a general subsidence accompanied by more localized uplifts.

PLACE OF ERUPTION OF THE BASALT.

There is no evidence of the existence of ash cones or tuff volcanoes within this part of the Columbia River lava formation, and it is thus more probable that the eruption of the fluid rock took place, without explosive action, from fissures from which the basalt flowed readily and continuously. No dikes of basalt were, however, observed in the foothills of the Clearwater Mountains, and we are thus forced to seek the focus of the eruption elsewhere. Only one local center of eruption has thus far been discovered. This locality is in the Eagle Creek Range, Oregon, and has been described in detail in a previous report.[a] A perfect network of basalt dikes here intersect the schists and granites near Cornucopia at elevations of about 7,000 to 8,000 feet, and immediately below this place the lava plateau begins.

While the total thickness of the sheets sometimes reaches 4,000 feet, the average depth of the Columbia River lava is ordinarily much less in the region here described, 3,000 feet being probably the maximum and 2,000 feet possibly the average.

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[a] Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pp. 740-745.

COEUR D'ALENE MOUNTAINS.

The geology of these mountains is practically unknown, and this may be the excuse for publishing the following brief notes taken during 1899, on a trip from Lewiston to Spokane and thence across to Montana by way of Mullan Pass. A short stay was made at the Coeur d'Alene mines, and such notes regarding these important lead deposits as are available will be found on page 108.

Going north from Lewiston on a branch of the Northern Pacific Railway one soon ascends the Uniontown Plateau, which has an elevation of 2,500 feet, and the route continues for 50 miles northward just west of the Washington-Idaho line, over a rolling open country of Columbia River lava, well cultivated and forming a part of the rich wheat lands of the "Palouse country." Spurs of older rocks project from the Coeur d'Alene Mountains and points of the same in places reach up above the general surface of the lava plateau. Of the former kind are the Cedar Mountains, near Moscow, Idaho, consisting of quartzite and granite, and the Tekoa Spur from the Moose Creek Mountains, which consists of slate. Of the latter kind are several quartzite points north of Pullman, as well as the Steptoe and Kamiack buttes described by Russell.[a] Fifteen miles from Spokane the road crosses an area of very decomposed granite, locally used for the manufacture of fire bricks, and descends to the Spokane River, which near Spokane is flanked by basalt flows. These are underlain by fluviatile or lacustrine clays, which are probably younger than the Columbia River lava.

From Tekoa a branch road runs up to Coeur d'Alene Lake and thence eastward across Mullan Pass into Montana. Along this line the formations seen are as follows:

After crossing slates and quartzites, a spur from the small complex known as the Moose Creek Mountain, the basalt begins again near Coeur d'Alene Lake and rises to bluffs forming a plateau 500 feet above the water (elevation about 2,500 feet). The Columbia River lava continues up the Coeur d'Alene River a few miles east of the lake, and then begins a sedimentary series of great thickness, which continues with west-northwest or northwest strike almost uninterruptedly to Missoula, Mont. The mountains consist of a maze of steep, narrow ridges, 1,000 to 3,000 feet high, the level crest lines of which have an elevation of from 5,000 to 6,500 feet. This region should be regarded as a very extensively dissected plateau. At first banded quartzitic slates prevail. North of Wardner the prevailing strike of the slates is N. 62° W. and the dip about 50° NNE. At Wardner the rock is a heavy-bedded gray quartzite, of medium grain; the bedding planes strike N. 70° W. with a dip of 60° SSW. Quartzite continues up to Burke and

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[a] Water-Sup. and Irr. Paper No. 34, U. S. Geol. Survey, 1900.

Mullan, occasionally with narrow intercalated bands of clay slate. A mass of granite breaks through the quartzite between Ninemile Creek and Canyon Creek at Burke and is believed to stand in some genetic connection with the ore deposits. Possibly this granite continues northward to Murray, where gold placers and veins have been found. From Mullan Pass the railroad follows down the St. Regis de Borgia River for 30 miles, where it joins the Missoula; from this point it skirts along the Missoula River for 60 miles to a point near the town of the same name. The general direction of the road is east-southeast from Mullan Pass. Along this whole distance the prevailing rock are banded quartzites and slates, which strike northwest and dip variably but generally at 30° to 50° NE. Interbedded with the quartzites 30 miles west of Missoula are purple slates similar to those found on Lolo Fork.

The whole series from Missoula to Coeur d'Alene Lake is evidently folded and compressed, and its thickness must be very great. Its age is unknown, but may well be pre-Cambrian.

ECONOMIC GEOLOGY.

GENERAL FEATURES.

Character of mineral deposits.—The valuable mineral deposits occurring in the area described in this report chiefly consist of fissure veins containing gold, together with associated placers, derived from the disintegration of the veins. Deposits containing lead and copper, usually also silver, occur also in several scattered places. Coal of an inferior quality has also been found in the upper Bitterroot Valley and in the lower Clearwater drainage. The lead-silver veins of the Coeur d'Alene Mountains are outside of the limits of this reconnaissance.

Distribution of deposits.—The metalliferous deposits are grouped in two belts. The first is along the western side of the Bitterroot Mountains, chiefly in Montana; the second is along the western foot of the Clearwater Mountains, in Idaho. The deposits of each of these two belts are again principally grouped in two regions forming the four corners of the mountain area involved, while the central part of the Clearwater Mountains appears to be practically barren. The four metalliferous areas are distributed as follows: The first occupies the lower Lolo Fork and the northern end of the Bitterroot Mountains; the second is found on the headwaters of the South Fork of Bitterroot River, and reaches over into Idaho, connecting with the mineral belts at Shoup and Gibbonsville; the third, the most important area, includes Elk City, Buffalo Hump, Dixie, and Florence, as well as numerous places along the South Fork of Clearwater River; the fourth area centers in Pierce, but also extends to the headwaters of Lolo Creek on the south and to the North Fork of the Clearwater on the north.

Character of ore.—The primary deposits are almost exclusively fissure veins and with them are associated extensive placers of an age ranging from Miocene or Pliocene to recent. In the northern Bitterroot Mountains and on Lolo Fork veins occurring in pre-Cambrian (?) schists chiefly contain copper, lead, and silver, although some gold is also found on Lolo Fork. The Curlew mine at the eastern foot of the Bitterroot Mountains contains argentiferous galena, and is located on a fissure between limestone (pre-Cambrian?) as the foot wall and, according to accounts, Pleistocene valley gravels as a hanging wall. The mine is not worked at the present time. On the upper Bitterroot River veins cutting porphyry likewise chiefly carry copper and silver, while argentiferous galena is also known from the Monitor mine, worked on a vein in gneiss on the divide between Bitterroot and Salmon rivers. Gold-bearing gravels have been mined for many years on Hughes Creek. Southward this belt connects with the gold-bearing deposits at Gibbonsville and Shoup. The rocks at Hughes Creek and Gibbonsville are pre-Cambrian (?) quartzites and slates.

West of these districts extends a wide granite area which as far as known is barren of mineral deposits. There can be no doubt that the Clearwater drainage was very thoroughly prospected for placers during the early days of mining, but outside of the South Fork very little of value has been found. In the upper part of the mountains the glaciation would naturally have swept away any placer deposits which may have existed, and in this denuded portion it is not impossible that veins may be found. Nothing of much value has been encountered up to the present time. A large vein containing silver is reported to occur on Rhodes Peak north of the Lolo trail. Along the Salmon River the conditions are probably more favorable and prospecting in the isolated region between Dixie and Shoup might possibly develop something of value.

As stated before, the western belt chiefly contains gold; only a few scattered copper deposits are known. The placers of Elk City and Florence are well known in the history of Idaho and are still worked to some extent. Veins which furnish the material for these placers are known to occur in all these localities; the principal mining districts are Florence, Dixie, Elk City, and Newsome Creek. The veins, chiefly occurring in gneiss, are almost exclusively of quartzose character and contain from 1 to 10 per cent of sulphurets, besides more or less native gold. The Buffalo Hump district, discovered in 1898, is situated on the high divide between the Clearwater and the Salmon, and contains in granite and slate many strong quartz veins, with a varying percentage of free gold and auriferous sulphides. Active work is in progress there at the present time. The northwestern mineral-bearing area contains placers along Lolo Creek, Musselshell Creek, and Oro Fino Creek. Many quartz veins of similar character to those from the southwestern belt are also worked in these districts. They are generally incased in schists; more rarely in granite. Veins of sulphide ores, containing gold and copper, occur in amphibolite close to Mount Idaho.

History and production.—The deposits on the eastern slope of mountains have not proved of great importance and have chiefly been discovered and worked at a comparatively recent time. The total production of all the mines on this side of the mountains probably does not exceed $1,000,000, of which the larger part has been derived from the Curlew mine on the north and from the placers of Hughes Creek, near the head of Bitterroot River. The important gold belt on the western slope was discovered about 1860, and very actively worked during the following years. Oro Fino, or Pierce, is reported to be the earliest discovery in Idaho. It was found in 1860, and during that season twenty-five men wintered there. The gravel near Pierce was not remarkably rich, but paid fairly well in 1861 and 1862.[a] In 1874 Pierce produced $70,000. Soon after this, however, the discoveries in Montana drew most of the miners away from this place, and in 1867 but little mining was going on. Since that time, however, the placers and quartz mines have been worked each year, although in a somewhat desultory manner. The total production is impossible to ascertain, but probably has not exceeded a few million dollars.

During late years placer mining has been carried on both in the low stream gravels and on the benches. There has also been a considerable activity in quartz mining, and several small mills have been built. The output of the placer mines in 1902 is estimated at $30,000, and that of the quartz veins at the same amount.

Elk City and vicinity proved to be of greater richness. Few quartz mines have been worked there, practically the whole production being derived from the placers. In 1863 or 1864 the white miners began to leave this field, which they considered about worked out, and for nearly thirty years there were only two or three of them left in the district, which was almost entirely turned over to the Chinese. In 1892 the white miners began to come back, and the Chinese simultaneously disappeared, very few of the latter being left now. A certain amount of placer work is still done in this vicinity each year, chiefly on bench gravels. The bars of the Clearwater River, which were worked extensively during the early days, are still occasionally washed. Regarding the total output of Elk City no satisfactory figures are available, but not unlikely the production amounts to between $5,000,000 and $10,000,000.

After the first few years of abundant production the output fell rapidly. In 1874 Elk City (including Newsome Creek and Clearwater station) produced $120,000. From 1882 to 1887 the Elk City district produced from $35,000 to $73,000 per annum. During the recent years the output has again increased, due to the introduction of dredging and hydraulic operation, and during the last years has probably been from $20,000 to $40,000. Very similar were the conditions during later years in Florence, which camp has been described in a previous report.[a] The total output of Florence was, however, considerably larger than at Elk City.

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[a] Browne, J. Ross, Report on Mineral Resources, Washington, 1868.

Florence, Warren, and Elk City are situated in Idaho County. According to the mint reports this county has, since 1880, produced an average of $200,000 per annum, or a total of about $6,000,000. Something like one-half of this amount probably comes from Warren, leaving $3,000,000 for the two last camps for the last twenty years. Pierce is located in Shoshone County.[b]

It is somewhat surprising that in spite of the recent activity in prospecting and working quartz veins the production of Idaho County should have decreased during the last few years. The mint reports give for Idaho County:

Production of precious metals in Idaho County, Idaho.

1895	$243,700
1896	155,350
1897	236,500
1898	203,500
1899	166,000
1900	152,000
1901	161,500
1902	157,023

Geological relations.—Nearly all of the vein deposits occur in granite-gneiss or metamorphic slates and schists; the prevailing strike of the veins seems to be in an east-west direction. The granite, which is the prevailing rock, represents the northward continuation of the great area of central Idaho north of Snake River. Gold-bearing veins occur both within this area and along its contacts with the surrounding older sedimentary rocks.

Within the region here discussed a peculiar relation obtains. The large central areas of granite, whether sheared, as along the eastern margin of the Bitterroot Mountains, or massive, as usually is the case, seem conspicuously barren of deposits. The vein systems appear in or close to the four smaller areas of sedimentary or metamorphic rocks which are found at the periphery of the great central granite area. It is thus in the quartzitic series of Lolo Fork, in the quartzites, slates, and gneisses of the upper South Fork of the Bitterroot, and in the old gneiss areas of Elk City and Pierce. While the age of the quartz veins is not established beyond doubt, it is probable that they were formed during the latter part of the Mesozoic era.

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[a] The gold and silver veins of Silver City, De Lamar, and other mining districts in Idaho: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900, p. 233.

[b] Ibid., p. 238.

UPPER SOUTH FORK OF THE BITTERROOT.

Trapper Creek.—No deposits are known to occur south of the locality just described until the southern end of the range is reached; no placers have been worked and the creeks appear to be barren of even traces of gold. A quartz vein was noted on Trapper Creek, near the south end of the range and about 3½ miles from the mouth of the canyon. This is a shear zone 6 to 8 feet wide, occurring in granite, and containing several stringers of quartz. The strike is north-south and the vein stands nearly vertical. An assay was made of the quartz from this prospect, the result showing 0.06 ounce of gold and 0.30 ounce of silver per ton. No deposits of any kind have been reported from the Nez Perce Pass, or the creek leading up to the pass.

Slate Creek.—About 18 miles south of the forks of the river Slate Creek joins it from the east. On this tributary are located several veins which were visited by Mr. G. W. Stose. The elevation at the mouth of Slate Creek is 4,700 feet. Near the entrance to the gulch are four or five cuts on the north slope on quartz veins containing calcite and tetrahedrite. These prospects are contained in granite-porphyry. On Slate Creek, several miles above its mouth, a well-defined vein crosses it with a direction a little west of north. On this vein, which cuts through granite, quartzite, and porphyry several locations have been made. The one next the creek is called the Moon mine, and is continued southward into the "Tiptop." At this place is exposed 6 feet of quartz dipping steeply to the west. The ore contains bornite, chalcopyrite, and tetrahedrite. The third location visited is "Dynamo" which is developed by a shaft 35 feet deep. Other prospects are located a short distance north of the Dynamo and among them is mentioned the Empire and the Carney. These are said to contain galena and chalcopyrite. It is not known that any of the prospects on Slate Creek have any considerable production to their credit.

Hughes Creek.—Eight miles south of Slate Creek, and about 10 miles north of the Salmon River divide, Hughes Creek joins Bitterroot River from the east. At its mouth is located the post-office of Alta (elevation 5,160 feet). The rock exposed here and for long distances above on the gulch is a heavy-bedded quartzite. For about 10 miles above the mouth the creek has a rather wide bottom with occasional meadows. In places the width of the bottom lands is a quarter of a mile. The walls of the canyon ascend with steep slope to a thousand feet or more above the bottom. Hughes Creek is known since the early days of mining as gold-bearing, and a continuous string of claims cover the bottom from the mouth up to the divide, 15 miles distant. For 10 miles above the mouth the gravels are deep, and bed rock has not been reached. At present the principal operations are carried on in the upper part of the creek.

The gold is generally coarse and occurs in flat grains accompanied by garnets and black sand. All along, gravel terraces accompany the watercourse, although in many places they have been removed by erosion. Near the mouth there is a gravel bar 50 feet above the stream, and another one 200 feet above the same. Evidences of still higher gravel bars are found up to an elevation of 500 feet above the bottom, and many claims are located on these high bars. Whether any of these occupying larger areas near the mouth of the creek will pay for working is not certain.

In 1899 at least three companies were working the creek, the first consisting of Orton, Molloy & Co. These men were ground sluicing—shoveling the material into the sluice boxes. A little higher up are the Keating claims. One mile above this the Wood Placer Company was beginning operations on a larger scale, using an elevator. In 1902 it was reported that the Wood Placer mines had been purchased by eastern capital and that a 4-mile ditch was being constructed which will furnish a pressure of 300 feet. The company expects to operate two giants. Stream tin is frequently found with the gold in this creek.

Johnson Creek, a few miles above Hughes Creek, is also said to contain a little gold.

Mineral Point.—This mining district is located about 6 miles north of the Salmon River divide, near the head of Bitterroot River, at the point where the stream splits up in several branches. The elevation is about 5,560 feet. The formation consists of quartzitic and chloritic schists. A number of copper-bearing veins have been located in this vicinity, and some small shipments are said to have been made. The first prospects are located on Woods Creek, about 1 mile west of the main river. The croppings are found near the contact of the quartzite with gneiss or pegmatitic granite. The developments are very slight. The rusty, decomposed ore shows pyrite, limonite, and azurite. The principal prospect in the Mineral Point district is said to be the Copper Queen, located near the road at the upper end of the meadows on the main fork. The ores are principally chalcopyrite, containing a little gold and silver; none of the gold is free. The showings on the surface were good, but a 400-foot tunnel run 100 feet below the croppings only developed schists impregnated with pyrite containing a little gold and copper. The best ore of the Copper Queen contained, it is said, from 5 to 20 per cent of copper and 11 ounces of silver, with a few dollars in gold per ton. Many other irregular veins of quartz stained with copper and showing evidence of considerable pressure and deformation were noted in the vicinity.

Up toward the adjacent district of Mineral Hill are several veins in granite or gneiss containing galena and arsenopyrite with from 6 to 24 ounces of silver per ton. The prevailing strike is northeast and southwest, while the veins generally dip 70° S.

Mineral Hill.—This district adjoins Mineral Point on the south and is chiefly located on the upper slopes of the hills which descend toward Salmon River. South of it, and almost connecting with it, is the gold-mining district of Shoup, in the canyon of the Salmon River. This, however, was not visited.

The veins of Mineral Hill are chiefly located in the upper part of Owl Creek, on the ridge south of Blue Nose Mountain, and also in the upper part of Horse Creek. The veins occur in a coarse gneiss cut by many dikes of granite. The only prospect worked in 1899 was the Monitor, located at the head of Owl Creek, at an elevation of 7,500 feet. A road was being built about this place from the headwaters of Bitterroot River. The Monitor is a 5-foot quartz vein with an east-west strike and containing scattered bunches of galena. A shaft was sunk on it to a depth of 50 feet and a considerable amount of ore has been shipped. It contained lead, with up to 100 ounces of silver, and a little gold.

Near the head of Horse Creek, at an elevation of 6,900 feet, are several veins striking east and west and dipping 40° N. The quartz contains a little galena and pyrite and is slightly copper stained. Several tunnels have been run on these veins which, however, at the time of visit, appeared to be abandoned.

GIBBONSVILLE DISTRICT.

The Gibbonsville mining district is located in Idaho, on a tributary of Salmon River, and only about 10 miles distant in a straight line east of the Mineral Hill district just described. Gold-bearing quartz veins are found near Gibbonsville, and have been worked for many years with varying success. Some years ago the American Development and Mining Company, who owned the principal mines in the district, introduced barrel chlorination to treat the ores. This was not found to be in all respects satisfactory, and lately a cyanide process has taken its place. The district was visited by Mr. W. H. Weed in 1898, who kindly put the following notes at my disposal: The rocks at Gibbonsville are steely gray, quartzose, and micaceous slates, thinly laminated. The slates strike north and south, and dip from 35° to 65° to the east or to the west. The quartz veins run nearly east and west, sometimes southeast and northwest, while the dip is northerly. The main tunnel by the American Development and Mining Company cuts at least six veins, with sharp, smooth walls, varying in thickness from a few inches up to 15 inches. The quartz carries abundant pyrite, and contains from $30 to $50 in gold, together with about $1 in silver. The oxidized part of the veins is free-milling, while below that zone very little native gold appears. Occasionally the quartz veins are banded or ribboned by parallel fracture planes. While the veins are very persistent, they are not uniformly ore-bearing, and no absolute regularity of the distribution of the ore has been observed.

ELK CITY DISTRICT.

PLACER MINES.

Important placer mines have been worked for many years on the upper tributaries of the South Fork of the Clearwater, this whole producing region being referred to as the "Elk City district." Placers occur on Red River and its numerous tributaries, on Red Horse Creek, American Creek, and Elk Creek; finally, on Crooked River, Moose Creek, and Newsome Creek. Below this point the gravel bars of the South Fork have been mined for many miles—at least, in places—as far down as Stuart, at its junction with the main fork of the Clearwater. The Elk City diggings were discovered in 1861. During the following years the activity was great, and the production doubtless amounted to several million dollars. The gravels in the bottoms of the streams were generally too low to be easily reached, and most of the operations were confined to the high bars and gravel terraces. In many places in the vicinity of Elk City the so-called "skim" diggings yielded largely, this class of deposits embracing the shallow concentrations of placer gold over large areas within a foot or two of the surface. For many years after the first few seasons of heavy production the camp was turned over to the Chinese. Renewed interests in the placers were, however, taken by white men during the last ten years, and in 1899 several deposits were actively worked on a fairly large scale.

The production of this district has been referred to on page 84. Suffice it to say that since 1875 it has yielded something like $30,000 to $70,000 per annum. As there is a fairly large amount of workable deposits remaining, a moderate output will probably be continued for many years; very likely, however, with a decreasing tendency. A map on a larger scale is shown in fig. 7.

Red River.—Coming down into Red River from the Nez Perce trail much quartz-gravel is seen in the main stream and its tributaries. In many of the latter are abundant evidences of old and extensive placer mining. At French Creek, a tributary entering Red River from the north a short distance below the post-office of Raymond, and at an elevation of about 4,500 feet, a dredger was working the old tailings and the gravels underneath them. This dredger is owned by the same company which was operating the hydraulic mine at American Hill.

Along Red River, bottom lands and meadows extend from Ryan's ranch for 6 miles down. Below this point the river flows in a narrow canyon, opening up again near the mouth of American River and Elk Creek. Many placer mines are located along the gulch gravels of Red Horse Creek, which heads near Anderson Butte and empties at the lower end of the Red River meadows. Within this upper basin just described there are few evidences of terraces or high gravels, but a different condition of affairs appears as soon as the basin of Elk Creek and the American River is entered.

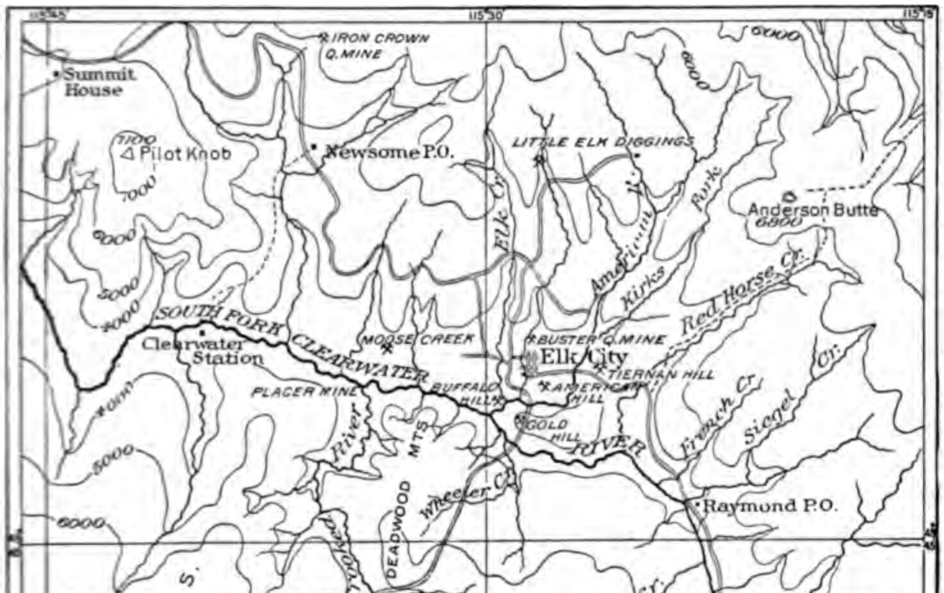

FIG. 7—Map of upper South Fork of Clearwater River, showing location of mining districts.

The basin of Elk Creek and American River is occupied by a system of gravel benches filling the basin to an elevation of somewhat over 4,500 feet.

From any prominent point the level of this gravel terrace is seen to skirt the valley for a long distance westward, and the higher mountains of Newsome Creek rise with more decided slope from this general level of deposition. For 2 or 3 miles above its mouth Elk Creek, emptying into the South Fork of the Clearwater from the north, contains broad bottom lands and meadows. A first bench is marked fairly clearly 50 feet above the creek and is covered with well-washed quartz gravel. This bench is well exposed at the little settlement of Elk City. On Little Elk Creek, about 3 miles above its mouth, the bottom lands narrow, and gravel ridges 100 feet high rise on both sides of the stream. At about 325 feet above Elk City, or an elevation of 4,525 feet, the above-mentioned prominent level of deposition is reached. This terrace of well-washed gravel is seen to skirt the ridges separating Elk Creek from Newsome Creek and continues across the divide between Elk Creek and the headwaters of American River. Remains of this same gravel terrace are also found in the Crooked River basin, although here a more active erosion has removed a larger part of these old deposits.

American Hill.—The most prominent gravel mine worked in 1899 is located at American Hill 1 mile southeast of Elk City, at an elevation of 4,200 feet, the elevation at Elk City in the upper part of the town being 4,200 feet approximately. The deposit at American Hill is owned by the Idaho Mining Company. About thirty years ago a little work was done here, chiefly in the nature of "skim" diggings and some drifting. The present company eight years ago removed the gravel down to the bed rock and exposed an old channel of the American River running from northeast to southwest. One thousand miner's inches of water is used, and an elevator raises the gravel to a series of sluices aggregating 500 feet in length and having a grade of 5 inches in 12 feet. Aneroid measurements gave the approximate elevation of the bed rock as 4,165 feet, or about equal to the lower portion of Elk City, and not much higher than the bed of American River a short distance south of the mine. The bed rock consists of a soft, coarse gneiss intruded by abundant pegmatitic veins. The gold is fairly coarse, much of it being of the size of wheat grains. The slope of the bed rock is said to be from 3° to 4° W.; the banks exposed in the pit, which has an area of about 700 by 200 feet, are from 60 to 100 feet high; the material exposed is prevailingly of a sandy character.

The top stratum consists of 10 feet of gravel and clay. This stratum was rich and worked in the early days as "skim" diggings. Below this follow 50 feet of sand, clay, and gravel interstratified. The lower portion of the deposit consists of 20 feet of red gravel, underneath which is found 15 to 20 feet of bluish gravel which contains the principal quantity of gold. The gravel is mostly quartzose, and the large bowlders on the bed rock often contain native coarse gold. On the south side of the pit the workings have exposed a decided bluff of bed rock 30 feet above the general level of the bottom of the channel. Not unlikely this represents a fault since the deposition of the gravel.

Tiernan Diggings.—A few miles above American Hill on the river of the same name are located some high gravels of considerable interest. The place is close to the road from Elk City to Raymond. The gravels are considerably higher than those at American Hill and they probably do not belong to the same system of channels. Going east from Elk City a high ridge of gneiss is crossed. Descending again to American River a distinct bench covered with wash gravel is noted at an elevation of 4,300 feet. At the bridge the elevation is about 150 feet less and the exposures consist chiefly of gneiss.

Tiernan Hill is situated on the east side of the river, a short distance from the bridge. The bed rock has an elevation of 4,450 feet and the top of the bank 4,580 feet. On the uneven bed rock lie thus 130 feet of sediments, chiefly consisting of sand and clay with some interstratified gravels. In former years a considerable amount of hydraulic work was done at this locality and the amount of remaining gravel is probably not large. In elevation, Tiernan Hill corresponds to the high terrace skirting the Elk Creek basin, but is, if anything, somewhat higher than this. It has the appearance as if this deposit formed a part of a larger channel, the central bed of which has been removed by erosion. A little work is still done each year.

Buffalo Hill.—The gravel mine of this name is situated on the north side of American River about a mile and a half southwest of Elk City, and near the point where Elk Creek empties into that stream. Something like 180 acres of gravel are contained in this isolated area. The larger part of this has already been mined by hydraulic operations, though a considerable quantity of poorer gravel still remains. Active work was in progress during 1899. The available fall is slight, hence there is some difficulty in disposing of the tailings. The flume is 2,000 feet long and has a grade of 3 inches in 12 feet, wooden riffle blocks being used. The size of the flume is 4 by 4 feet. The principal operations have been carried on on the north side of the hill, where several acres of bed rock are exposed. In front of this lies a considerable mass of tailings.

The bed rock is throughout a soft, coarse gneiss of the kind so prevalent about Elk City. The configuration of the bed rock shows plainly that the deposit is a part of an old channel of the American River. A high rim lies immediately north of that stream and is 150 feet above it. North from this rim the bed rock descends until at the principal pit the elevation is about equal to that of the bed of the American River. According to aneroid measurements, the elevation is 4,150 feet, or about 50 feet lower than the average elevation of Elk City.

The exposed banks show 40 feet of prevailing sand with some gravel. A somewhat coarse gravel rests immediately on the bed rock and consists chiefly of cobbles of quartz with some gneiss and also a large amount of black quartzite; the latter is probably derived from an area exposed on Relief Creek a few miles southward.

The gold is both of a fine and coarse variety, hence the necessity for long sluices. It is as usual principally scattered on the bed rock.

North of Buffalo Hill, on Buffalo and Blackfoot gulches, the ordinary bed rock is exposed, although still higher up gravel of the upper terraces is encountered. A very interesting feature is the exposure in the hydraulic pit of the mine of a few acres of so-called "false" bed rock. This consists of a series of heavy-bedded clays containing much coaly material, and is evidently a part of a sedimentary series resembling lake beds which prior to the accumulation of the gravels covered a part of this country. On the northwest the clays border against gneiss, the separating plane being a well-defined perpendicular fault line, the downthrow being on the southeast side.

A mile to the southeast of Buffalo Hill is Gold Hill, situated on the point between Red River and American River. The elevation of the bed rock on the south side of the road is here 4,300 feet; these gravels are thus 150 feet higher than those of Buffalo Hill. The thickness of the gravel at this point does not seem to be considerable. Washing on a small scale is carried on at this point each year.

South of Red River the road from Elk City to Crooked River ascends Wheeler Creek, along which shallow diggings are found at intervals at elevations from 4,200 to 4,250 feet. The flat bottom of this stream has been ground-sluiced all the way up to the divide toward Crooked River, which has an elevation of 4,900 feet. Much of the gravel is of a subangular character. A few well-washed quartz pebbles were noted almost up to the divide.

Crooked River.—The road from Elk City to the head of Crooked River descends to the latter by way of Relief Creek. In the flat bottom of this, evidence of old placer diggings are found. Quartzite cobbles are very abundant, but no great amount of bench gravels were seen. Crooked River and the gulches emptying into it have been worked for several miles above this point. The gravel chiefly consists of the present accumulations in the creek, together with smaller amounts of low bench gravels. The mouth of Crooked River was not visited, but it is reported that the Tacoma and Clearwater Mining Company was operating a hydraulic mine near this place.

Little Elk Creek.—Three miles north of Elk City the Little Elk Mining Company was preparing to wash the shallow gravels spread out over the bottom of this creek. A short distance north of this point the actual gneiss bed rock appears in the creek bottom, but the material on which the gravel rests at this mine is what is usually termed "false" bed rock. This consists here of clays and micaceous sands with a considerable amount of coaly material. It is exposed at two places below the pay gravel and has a dip of 60° E. These beds have very much the appearance of being deposited in a broad river or lake and present great similarity to the beds of the same kind observed at Buffalo Hill.

Newsome Creek basin.—About 6 miles due west of Elk City the Moose Creek diggings are located on the ridge dividing the creek of the same name from Newsome. The place was not visited, but from accounts the deposit appears to be of the same kind as that exposed at Buffalo Hill. The banks are said to be 160 feet in height, the gold, both coarse and fine, varying from $16 to $19.20 per ounce. This mine was operated in 1899.

From Buffalo Hill the road to Harpster, on the Clearwater River, ascends over a long ridge of wash gravel. The top of the terrace, which is the same as observed on the headwaters of American River, has an elevation of about 4,450 feet. Scattered wash occurs above this point up to an elevation of 4,750 feet. Above this point the gneiss rises in low ridges. The same gravel terrace continues into the drainage of Newsome Creek. This stream has been washed all along its course, as have also the benches which accompany it at an elevation of 30 feet above the water. The bottom is generally flat and filled with tailings to a width of 100 or 200 feet. An important gravel terrace appears 300 feet above the creek and is well exposed both on the east and west side of Newsome post-office. The elevation of the bench is 4,400 feet. These high bench gravels have not been generally washed, though placer operations are frequently carried on in the small gulches which traverse the terrace and in which a secondary concentration has taken place.

Along the South Fork of the Clearwater the low bars have been mined for many miles downstream; at least as far down as Stuart. High gravels corresponding to those of American River and Newsome Creek were not observed. There are, however, occasional small gravel benches 200 feet above the river. In many cases these have also been washed. The present production from this kind of mining is doubtless very small.

QUARTZ VEINS.

For many miles west of the mining districts at the head of the Bitterroot River there are no indications at all of mineral deposits until the drainage of the Red River is entered, this being a tributary to the South Fork of the Clearwater River. Near the head of Red River, on the Nez Perce trail, between Ten Dollar and Mountain Meadows, the first indications of quartz veins are found, and a few prospect holes have been opened on the ridges, which are covered by a

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The principal producing mine is situated near the head of the river and practically on the divide separating this drainage from the Salmon River. It is called the Badger mine and a few years ago was the scene of active mining operations. A 10-stamp mill was built on the Crooked River about 5 miles northeast of Buffalo Hump and a road constructed from there to the mine. The vein is said to occur in granite and is a normal quartz vein containing a considerable amount of free gold.

Another vein, called the "Homestake," is situated on the road to the Badger mine, 1,300 feet above the mill and at an elevation of about 6,400 feet. The Homestake crops in granite and has a strike of N. 80° W., the dip being 70 N. The vein appears to be only from 2 to 3 feet wide and is developed by two tunnels 100 feet apart. The ore is a white normal quartz containing pyrite and a little galena.

During 1902 the Crooked River Mining and Milling Company is reported to have completed a 20-stamp mill at Oro Grande, on the Crooked River, 12 miles in a southerly direction from Elk City and three-fourths of a mile below the old Badger town and the forks of Crooked River. The deposit which has been developed during 1902 is said to be a very wide mineralized belt of low-grade free-milling ore, striking north and south. The mining and milling expenses are claimed to be less than 50 cents per ton. The same company owns the Orion and the Regnier quartz veins in the same district. New discoveries of veins are also reported 3 miles below Oro Grande and north of Deadwood Mountain and Relief Creek.

In 1901 the following companies have reported production of gold and silver from the Elk City district: Gold Hill Placer Company, Little Elk Mining Company, Tiernan placers, Relief Creek placers, American Hill placers.

DIXIE DISTRICT.

A mining camp which is of small extent, but which has maintained a certain production for many years, is located at Dixie, on the headwaters of Crooked Creek, which drains into Salmon River almost due south of the point where the larger stream of the same name enters the Clearwater River. The locality was not visited. A wagon road extends to it from Elk City, following up Red River to near Ryans Meadow, and continuing thence southward. The placers of Dixie camp consist partly of the gravels in the creek beds and to some extent of higher benches. Cinnabar is said to have been found in the gravels, with the gold. Numerous smaller gold-quartz veins are reported to exist near the camp, and have been worked at intervals on a small scale. During 1899 considerable prospecting was in progress in the country between Dixie and the Badger mine, about 8 miles farther west, and promising veins are reported to have been uncovered.

accessible by means of trails, one leading up from Crooked River and another one, more frequently used, from Grangeville. The latter route followed the Florence road about 20 miles southward to Adams camp, from which place a trail continued to Buffalo Hump, leading over high and bare ridges. It is reported that shortly after that date a wagon road was constructed, following the last-named trail. The general drainage and the location of principal claims is illustrated on fig. 8, reduced from a map by Mr. W. H. Hill.

From the Badger mill located on Crooked River, the trail ascends westward over sloping ridges to a broad divide covered with thick forest. From this point it descends into Lake Creek, a long tributary to the Salmon River, heading on the east side of Buffalo Hump. When Lake Creek is reached the trail turns up the same, following it over heavy moraines, ascending about 3,000 feet. The divide at the head of Lake Creek has an elevation of nearly 8,000 feet. West of it, and at the foot of Buffalo Hump, extends a flat, marshy in places, and containing several small lakes or ponds.

The predominating rock at Buffalo Hump is the ordinary Clearwater granite of light-gray color, and containing both biotite and muscovite. It is on the whole very similar to the large areas of the same rock which extend to the south of Salmon River in the vicinity of Warren camp. Near Buffalo Hump this granite contains a number of irregular patches and smaller areas of micaceous schist, quartzites, and coarse granular marbles, the latter very largely converted into greenish and brownish hornfels and garnetiferous rocks. The strike and dip of this sedimentary series are extremely variable, but are usually at moderate angles of 30° to 40° to the east or north. It is evident that this sedimentary series has been intruded by the granite and suffered intense contact metamorphism. The schists are penetrated by granitic dikes, running in all directions. Regarding the age of the schists, nothing more definite can be said than that they are older than the intruding granite. No other sedimentary areas are known in the vicinity with which they can be even tentatively connected. The granite often shows two well-marked systems of joint planes, one having a northeasterly and the other a northwesterly direction. Mr. Charles L. Whittle,[a] who has published a short but interesting article on the district, states that "along the northeasterly set of joints, and to a less extent along the northwest set, there have been introduced small quartz veins in great abundance. These veins are the oldest in the camp and vary in width from mere films up to several feet, the great majority being about 1 inch across. These small veins seldom appear mineralized and usually lack permanence, either horizontally or vertically." The producing veins form a linked system diverging slightly northward and having a strike of a few degrees east of north, the dip being generally very steep toward the east. The first vein discovered was called the "Big Buffalo." This claim is situated on the high plateau already referred to. A 10 by 12 foot shaft was sunk to a depth of 72 feet in 1899 and the drifts and crosscuts amounted to 100 feet. The dump covered a large part of the outcrop, in which the vein was stated to have a width of 40 feet. In a cut just north of the shaft about 12 feet of vein quartz were exposed. The ore is a normal, milky-white quartz containing scattered masses of pyrite, galena, copper pyrite and tetrahedrite. An assay of some of the material from the dump gave the high result of nearly 8 ounces of gold and 7 ounces of silver per ton. It is stated that the Big Buffalo vein can be traced southward through three claims and is then lost along the line of the east and west valley of Sheep Creek, which drains the high plateau in a westerly direction and finally turns southward toward the canyon of the Salmon River.

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[a] Eng. and Min. Jour., vol. 68, 1899, pp. 215, 216.

A few claims south of the Big Buffalo is the Fortune vein. This was found to have a strike of N. 10° E. and a steep easterly dip. Two feet of quartz showed between well-defined walls and contained scattered crystals of pyrite.

A short distance east of the Big Buffalo another prominent vein appears and is continuous for a distance of 1 mile. Near the north end of this is the Monte Cristo claim, which in 1899 was developed by several small tunnels. The vein appears between granite walls. This is continued southward by the St. Louis and other claims, showing again a well-defined quartz vein from 3 to 6 feet wide. The normal vein quartz contains small grains of pyrite, chalcopyrite, galena, and zinc blende. An assay of a sample taken from a prospect hole 10 feet deep on the St. Louis gave 3.4 ounces of gold and 9.2 ounces of silver per ton. Still farther south on what appears to be the same vein is located the Jumbo. On this claim the deposit has been opened by two tunnels, the lower one 300 feet in length. The vein appears of fair size and of a fairly uniform thickness for several feet. Here again the quartz contains a little iron pyrite, tetrahedrite, and chalcopyrite.

On the eastern side of the camp, at the head of Lake Creek, a great number of prospects were located, the most important of which were called the Vesuvius, Crackerjack, and Winslow. On all of these active work was in progress and fair ore was exposed. Owing to the glaciated character of the country, there is but little decomposed vein matter with free gold. Ordinarily shallow prospect holes will reach fresh sulphides. It is stated that the quartz is free milling, although it seems probable that the larger part of the values are contained in the sulphurets.

mittently and on a small scale. Ten miles northeast of Pierce on French Creek, tributary to the North Fork of the Clearwater, are two quartz veins half a mile apart, and called the Golden West and Klondike. Among the important veins north of Pierce is mentioned the Sweet mine, which from 1894 to 1896 is reported to have produced $40,000. The Mascot vein is situated 15 miles northwest of Pierce, and was operated during 1899. The equipment consists of two steam stamps. The veins in the vicinity of Pierce are reported to have a southwesterly dip of about 45°. Below the shallow zone of oxidation the ore is apt to turn base, as indeed is suggested by the low grade of the placer gold.

Prof. I. C. Russell,[a] who visited the Mascot Hills to the west of Pierce, says that the rocks there "contain numerous small gash veins, but do not reveal the presence of any true lodes or fissure veins."

In 1901 the following properties reported production of gold and silver:

Vi-Vi placers.
Last Show placers.
Woodchuck placers.
Monahassett placers.
Boggs Gulch placers.
Missouri Rose placers.
May Creek placers.
Wild Rose quartz.
Boise quartz.
Fisher quartz.
Venus quartz.

For 1902 the following report is available:

The Wild Rose, owned by Dunn and Wilkinson, Pierce, Idaho, has been operating a 3-stamp mill in 1901 and 1902, and made a good clean up. Developments amount to 460 feet. The Santiago group, owned by Wilsey & Co., of Pierce, has operated a 2-stamp mill the entire season. The Mascot Mining and Milling Company, of Pierce, has operated its 10-stamp mill part of the season. The Ozark Company, owned by Gaffney and Pond, of Pierce, also has a mill which has been producing during the season. The Dewey is operated by Ellis & Co., who are making arrangements for the erection of a 5-stamp mill. The French Creek Mining and Development Company were erecting a new mill and expected to run it during the winter of 1902-3.

The placer property owned by the American Placer Mining Company, on Oro Fino Creek, was in operation the first part of the year, but closed down in July on account of low water. This company is installing an elevator plant with 7 miles of ditch and flume, and own about 10 miles of placer ground below Pierce. Two placer-mining companies are preparing to work French Creek by means of bed-rock flumes. An elevator was being operated during the summer of 1902 on Gold Creek, 20 miles northwest of Pierce.

From these reports it will be seen that a great number of quartz prospects are actively developed near Pierce. The aggregate production of the Pierce mining district now probably exceeds that of Elk City. The output of the camp in 1902 is estimated to be $30,000 from placers and about the same amount from quartz veins. These data have been obtained from Dr. D. T. Day, of the division of mining and mineral resources of the United States Geological Survey, through Mr. V. C. Heikes, field assistant.

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[a] Water-Sup. and Irr. Paper No. 54, U. S. Geol. Survey, 1901, p. 128.

MUSSELSHELL AND LOLO CREEKS.

Lolo Creek heads near Rocky Ridge between the Lochsa and the North Fork, and after a tortuous course empties into the main Clearwater at Greers Ferry, a few miles above the mouth of Oro Fino Creek. In its upper course it is joined by Musselshell Creek, which heads in the same vicinity. The latter creek has been mined all the way, although no extraordinary richness is reported. Lolo Creek has been washed for gold in places, but ordinarily contains too many bowlders. The gold, like that of Pierce, is fine in size but of low grade, varying in value from $17 to $15 per ounce. A number of quartz veins are reported from the head of these two creeks, and the district may be considered as the southeasterly extension of the gold-bearing area of Pierce and the Mascot Hills. A prospect called the Pioneer was worked in 1899 and is situated on the low ridges between Musselshell and Lolo creeks, 10 miles east of Weippe. The vein strikes N. 70° E. and dips 85° S.

DEPOSITS BETWEEN CLEARWATER AND SNAKE RIVERS.

In the plateau country extending between Clearwater and Snake rivers the Columbia River lava covers nearly the whole area, though bed rock is occasionally exposed in the deep cuts of the canyons or in points protruding through the lava. No placer mines of importance have been worked in this area. The bottom gravels and bars of Salmon River and of Snake River contain gold, however, and these have been worked to some extent. Along Salmon River, especially where the gold is less fine than along the Snake, placer operations have been carried on in different places during the last few years. The aggregate yield is, however, small.

Near Harpster and Mount Idaho.—Many small quartz veins have been located and partly developed along the South Fork of the Clearwater near Harpster. None of them have, however, proved rich. The rock inclosing them consists of black slate, diorite, and amphibolite. Some miles above Harpster, along the same river and only a few miles east of Mount Idaho, a few veins have been discovered and were prospected in 1899. These veins form a silicified and mineralized streak in greenstone-schists almost at the river level and on the west side of the stream. The strike is northeasterly and the dip 60° SE. The main tunnel shows principally an altered greenstone containing much pyrite.

slate bed rock being 80 feet above river level and the top of the sandy gravel 300 feet above the same. This bar was hydraulicked in 1897 by the Victor Mining Company, of Spokane. The pay is concentrated in a thin layer of cemented gravel on the bed rock.

A big gravel bar 200 feet high is situated higher up on the west side opposite Carver's ranch. The limestone bed rock is only a few feet above the river and on it rests cemented gravel, containing very coarse gold of local origin. This deposit has been mined by drifting along the bed rock. Another large bar with much sand lies at a bend of the river a little north of Fiddle Creek. Still another high bar on which some placer mining has been done is situated on the south side of the river a few miles above the great bend at Salmon Point. Above this point there are only smaller low bars but the sands of these contain fine gold everywhere.

COEUR D'ALENE MOUNTAINS.

What little is known about this subject, really outside of the limits of this reconnaissance, is given below. For notes on the geology see page 81.

GOLD DEPOSITS.

The Coeur d'Alene Mountains are not rich in known gold deposits. Placer mines of moderate richness have been worked in the Moose Creek diggings on a branch of the North Fork of the Clearwater, a short distance west of the Montana-Idaho line. Minor deposits have also been worked at the head of the Middle Fork of St. Josephs River and on the Montana side near the head of Cedar Creek halfway between Mullan Pass and Missoula.

The most important deposits, placers as well as quartz veins, are situated at Murray and Delta on the North Fork of the Coeur d'Alene River, 15 miles north of the lead-mining district.

LEAD-SILVER VEINS.

To this class belong the celebrated deposits near Wardner, Wallace, and Mullan on the Coeur d'Alene River,[a] which are estimated to have produced about $60,000,000 of lead and silver since their discovery fifteen years ago. The lowest profitable percentage of lead in the mined ore is said to be about 6 per cent. The ores are subjected to careful concentration in large dressing works.

The deposits are clearly defined fissure veins cutting fine-grained greenish quartzites and quartzitic slates of doubtful (though probably pre-Cambrian) age. The principal ores are galena and zincblende, but there is also much finely distributed pyrite. Chalcopyrite is ordinarily absent. These are practically the only metallic minerals, and recur in all the deposits. The principal gangue mineral is siderite, accompanied by minor quantities of quartz and barite. Fluorite is absent. The fissures along which the ore bodies appear are well defined, and sometimes continuous for one or more miles. The ore bodies do not show much clearly defined crustification or other evidence of having been deposited in open space. The siderite appears always as an undoubted product of replacement, while many veinlets of quartz have in part resulted from the filling of open small fissures. Evidences of gradual transitions from ore to country rock are abundant, and are especially prominent in the mines carrying low-grade ore, as, for instance, in the Helena and Frisco. In the exposures underground, as well as in the specimens and thin sections, the evidence of replacement is complete and positive.

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[a] For a brief description of these mines, including technical features, see J. R. Finlay, Trans. Am. Inst. Min. Eng., February and May, 1902.

The greenish-gray fine-grained quartzite which constitutes the prevailing country rock contains no sulphides when fresh. It is composed of small, rounded, or subangular quartz grains, closely packed—often, indeed, jointing closely, as in a normal quartzite. Usually, however, a little sericite, in bunches of small fibers, is present as cementing material between the grains. There are few other minerals, exept a little feldspar in clastic grains, small prisms of tourmaline, and some grains of calcite. Near the veins minute specks of siderite, zincblende, pyrite, and galena appear in this quartzite; and these scattered grains gradually merge into bodies of merchantable ore. The thin sections show how the rock near the veins is filled with small grains of branching and irregular form, which consist of siderite, developed by attack first upon the groundmass and then upon the grains of clastic quartz. Accompanying the siderite are small grains of zincblende, cubes of pyrite and irregularly wiry masses of galena. All these sulphides appear not only in or near the siderite, but also in the cementing sericite, and in the apparently perfectly fresh quartz grains.

At a more advanced stage these areas of siderite extend until they join, and thus completely replace the rock. In the resulting ore lie scattered many small quartz grains, representing remnants of the clastic constituents of the quartzite. Occasionally larger masses of zincblende appear to form directly in the quartzite by metasomatic replacement of the quartz. The sericite in the quartz then disappears, though once in a while small foils of it may be detected. During the transition stage, seams and narrow veinlets in the altering rock are filled with sericite, apparently segregated there, when driven out from the main mass. In other specimens from the Helena and Frisco mine, the replacing siderite has a strong tendency to idiomorphic development. Imperfect rhombohedral forms are often seen, sometimes cutting straight across the clastic grains. Certain specimens from the Bunker Hill and Sullivan mine show quartzose grayish masses of irregular outline, and apparently merging gradually into the normal greenish quartzite. These quartzose masses consist of very irregular interlocking grains of quartz, not in the least similar to the accessible by means of trails, one leading up from Crooked River and another one, more frequently used, from Grangeville. The latter route followed the Florence road about 20 miles southward to Adams camp, from which place a trail continued to Buffalo Hump, leading over high and bare ridges. It is reported that shortly after that date a wagon road was constructed, following the last-named trail. The general drainage and the location of principal claims is illustrated on fig. 8, reduced from a map by Mr. W. H. Hill.

From the Badger mill located on Crooked River, the trail ascends westward over sloping ridges to a broad divide covered with thick forest. From this point it descends into Lake Creek, a long tributary to the Salmon River, heading on the east side of Buffalo Hump. When Lake Creek is reached the trail turns up the same, following it over heavy moraines, ascending about 3,000 feet. The divide at the head of Lake Creek has an elevation of nearly 8,000 feet. West of it, and at the foot of Buffalo Hump, extends a flat, marshy in places, and containing several small lakes or ponds.

The predominating rock at Buffalo Hump is the ordinary Clearwater granite of light-gray color, and containing both biotite and muscovite. It is on the whole very similar to the large areas of the same rock which extend to the south of Salmon River in the vicinity of Warren camp. Near Buffalo Hump this granite contains a number of irregular patches and smaller areas of micaceous schist, quartzites, and coarse granular marbles, the latter very largely converted into greenish and brownish hornfels and garnetiferous rocks. The strike and dip of this sedimentary series are extremely variable, but are usually at moderate angles of 30° to 40° to the east or north. It is evident that this sedimentary series has been intruded by the granite and suffered intense contact metamorphism. The schists are penetrated by granitic dikes, running in all directions. Regarding the age of the schists, nothing more definite can be said than that they are older than the intruding granite. No other sedimentary areas are known in the vicinity with which they can be even tentatively connected. The granite often shows two well-marked systems of joint planes, one having a northeasterly and the other a northwesterly direction. Mr. Charles L. Whittle,[a] who has published a short but interesting article on the district, states that "along the northeasterly set of joints, and to a less extent along the northwest set, there have been introduced small quartz veins in great abundance. These veins are the oldest in the camp and vary in width from mere films up to several feet, the great majority being about 1 inch across. These small veins seldom appear mineralized and usually lack permanence, either horizontally or vertically." The producing veins form a linked system diverging slightly northward and having a strike of a few degrees east of north, the dip being generally very steep toward the east. The first vein discovered was called the "Big Buffalo." This claim is situated on the high plateau already referred to. A 10 by 12 foot shaft was sunk to a depth of 72 feet in 1899 and the drifts and crosscuts amounted to 100 feet. The dump covered a large part of the outcrop, in which the vein was stated to have a width of 40 feet. In a cut just north of the shaft about 12 feet of vein quartz were exposed. The ore is a normal, milky-white quartz containing scattered masses of pyrite, galena, copper pyrite and tetrahedrite. An assay of some of the material from the dump gave the high result of nearly 8 ounces of gold and 7 ounces of silver per ton. It is stated that the Big Buffalo vein can be traced southward through three claims and is then lost along the line of the east and west valley of Sheep Creek, which drains the high plateau in a westerly direction and finally turns southward toward the canyon of the Salmon River.

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[a] Eng. and Min. Jour., vol. 68, 1899, pp. 215, 216.

A few claims south of the Big Buffalo is the Fortune vein. This was found to have a strike of N. 10° E. and a steep easterly dip. Two feet of quartz showed between well-defined walls and contained scattered crystals of pyrite.

A short distance east of the Big Buffalo another prominent vein appears and is continuous for a distance of 1 mile. Near the north end of this is the Monte Cristo claim, which in 1899 was developed by several small tunnels. The vein appears between granite walls. This is continued southward by the St. Louis and other claims, showing again a well-defined quartz vein from 3 to 6 feet wide. The normal vein quartz contains small grains of pyrite, chalcopyrite, galena, and zinc blende. An assay of a sample taken from a prospect hole 10 feet deep on the St. Louis gave 3.4 ounces of gold and 9.2 ounces of silver per ton. Still farther south on what appears to be the same vein is located the Jumbo. On this claim the deposit has been opened by two tunnels, the lower one 300 feet in length. The vein appears of fair size and of a fairly uniform thickness for several feet. Here again the quartz contains a little iron pyrite, tetrahedrite, and chalcopyrite.

On the eastern side of the camp, at the head of Lake Creek, a great number of prospects were located, the most important of which were called the Vesuvius, Crackerjack, and Winslow. On all of these active work was in progress and fair ore was exposed. Owing to the glaciated character of the country, there is but little decomposed vein matter with free gold. Ordinarily shallow prospect holes will reach fresh sulphides. It is stated that the quartz is free milling, although it seems probable that the larger part of the values are contained in the sulphurets.

A number of placer claims have been located in the vicinity, but owing to the extensive glaciation it is probable that most of these will be disappointing in yield.

According to late information from Mr. V. C. Heikes, of the division of mining and mineral resources of the United States Geological Survey, the following properties were producing at Buffalo Hump in 1902: The Jumbo has been working 4 stamps during the year, and unverified reports placed the yield at $5,000 per month. On the Crackerjack a 5-stamp mill was running in September, and during that month treated about 400 tons of ore. In addition to concentrates and tailings the clean up from the plates for the month is given as $4,000.

On the Wise Boy a mill had been erected and was preparing to start on October 1. This claim is believed to contain ore of excellent quality.

The Buffalo Hump syndicate has been working 25 men, and the 10-stamp mill on the Big Buffalo has been operated steadily for the last ten months. Bullion has been shipped regularly.

In the article quoted above, Mr. Whittle expresses himself as follows:

> "I have been greatly disappointed to note the scarcity of free gold in the oxidized portions of the veins, and the sudden and universal thinning out of the prominent veins, their unequal pockety mineralization, and the strong tendency of the veins to pass from well-defined walls into a ramifying mass of small stringers within a short distance has filled me with apprehensions as to the future of the camp."

Judgment of the real character of the veins would, however, best be deferred until the ore bodies shall have been thoroughly exploited. The result of the last two years' work shows that to some extent Mr. Whittle's predictions had a foundation. At the same time it is evident that some shoots of value have been encountered and that the camp will continue, for a long time, as a producer, though not on as large a scale as was predicted during the first boom.

PIERCE DISTRICT.

PLACERS.

The Pierce district was discovered in 1860, and for the first few years after that date a large production was maintained. Soon, however, most of the mining population was attracted to richer camps elsewhere and the production declined greatly. For the last ten years it has probably rarely exceeded $20,000 or $30,000 per annum. As in so many other cases, the total production is impossible to obtain. Probably the production was considerably less than at Elk City, which, in turn, was eclipsed by Florence, Warren, and the Idaho Basin. A guess may be hazarded that the total output of Pierce is in the vicinity of $5,000,000. A certain amount of placer mining is still done every year, and at intervals some of the numerous quartz veins are also operated. Pierce is situated near the head of Oro Fino Creek, which empties into the main Clearwater River 25 miles farther west. The elevation of the camp is in the vicinity of 3,000 feet. From the monotonous lava plateau extending about Weippe a wagon road leads to Pierce, a distance of about 12 miles. After a few miles of continued Columbia River lava, low hills of granite or imperfectly gneissoid rock rise, and over the same rocks the road finally descends to Oro Fino Creek. Pierce appears to be located at the contact of an extensive area of gneiss and mica-schist, which continues toward the northwest across the Mascot Hills to the North Fork of the Clearwater. South of the contact granitic and dioritic rocks prevail. Near the contact the schists are penetrated by granitic dikes. Below Pierce, Oro Fino Creek runs in a narrow canyon, which widens and splits up into two branches close to the settlement. The gravels worked are partly the low benches along the creek, partly also high terraces extending to a height of 500 feet above the stream. Canal Gulch extends northward from Pierce for several miles, heading at the divide toward the North Fork of the Clearwater. It has been extensively worked, and at least in one place a half-mile north of town a high gravel bench is still mined. At this place there appear to be two levels of terraces, one 100 feet above the creek, while the bed rock of the other one is 200 feet above the same level.

The bed rock is a coarse diorite. The banks are 50 feet high and the gravel contains a great abundance of quartz pebbles.

Above Pierce, Oro Fino Creek has been worked for several miles. On the road to Rhodes Gulch well-washed gravel extends to a height of 500 feet above the town. Rhodes Gulch, coming down from the north and joining the main Oro Fino Creek a few miles above the town, is also reported to have been very rich, which is also confirmed by the extensive dumps of washed gravel covering its bottom. East of this point is French Creek Mountain, and a road leads across to the quartz prospects which have been found there.

Altogether Oro Fino Creek has been washed for gold for a distance of 12 miles above and 10 miles below Pierce. The gold is usually fine as to size, but of low grade as to value, being, at most, worth $17 per ounce, some of it running as low as $15.

A few miles below Oro Fino, not far from the tributary called Poorman Creek, the American placer mine was in operation in 1899, washing the gravels of the creek bottom. The creek at this point flows over a basaltic bed rock.

QUARTZ VEINS.

As may be expected a number of quartz veins have been found and located near Pierce. None of them has, however, thus far reached the standing of large mines. As so often happens in districts of this kind they are worked intermittently and on a small scale. Ten miles northeast of Pierce on French Creek, tributary to the North Fork of the Clearwater, are two quartz veins half a mile apart, and called the Golden West and Klondike. Among the important veins north of Pierce is mentioned the Sweet mine, which from 1894 to 1896 is reported to have produced $40,000. The Mascot vein is situated 15 miles northwest of Pierce, and was operated during 1899. The equipment consists of two steam stamps. The veins in the vicinity of Pierce are reported to have a southwesterly dip of about 45°. Below the shallow zone of oxidation the ore is apt to turn base, as indeed is suggested by the low grade of the placer gold.

Prof. I. C. Russell,[a] who visited the Mascot Hills to the west of Pierce, says that the rocks there "contain numerous small gash veins, but do not reveal the presence of any true lodes or fissure veins."

In 1901 the following properties reported production of gold and silver:

Vi-Vi placers.
Last Show placers.
Woodchuck placers.
Monahassett placers.
Boggs Gulch placers.
Missouri Rose placers.
May Creek placers.
Wild Rose quartz.
Boise quartz.
Fisher quartz.
Venus quartz.

For 1902 the following report is available:

The Wild Rose, owned by Dunn and Wilkinson, Pierce, Idaho, has been operating a 3-stamp mill in 1901 and 1902, and made a good clean up. Developments amount to 460 feet. The Santiago group, owned by Wilsey & Co., of Pierce, has operated a 2-stamp mill the entire season. The Mascot Mining and Milling Company, of Pierce, has operated its 10-stamp mill part of the season. The Ozark Company, owned by Gaffney and Pond, of Pierce, also has a mill which has been producing during the season. The Dewey is operated by Ellis & Co., who are making arrangements for the erection of a 5-stamp mill. The French Creek Mining and Development Company were erecting a new mill and expected to run it during the winter of 1902–3.

The placer property owned by the American Placer Mining Company, on Oro Fino Creek, was in operation the first part of the year, but closed down in July on account of low water. This company is installing an elevator plant with 7 miles of ditch and flume, and own about 10 miles of placer ground below Pierce. Two placer-mining companies are preparing to work French Creek by means of bed-rock flumes. An elevator was being operated during the summer of 1902 on Gold Creek, 20 miles northwest of Pierce.

From these reports it will be seen that a great number of quartz prospects are actively developed near Pierce. The aggregate production of the Pierce mining district now probably exceeds that of Elk City. The output of the camp in 1902 is estimated to be $30,000 from placers and about the same amount from quartz veins. These data have been obtained from Dr. D. T. Day, of the division of mining and mineral resources of the United States Geological Survey, through Mr. V. C. Heikes, field assistant.

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[a] Water-Sup. and Irr. Paper No. 54, U. S. Geol. Survey, 1901, p. 128.

MUSSELSHELL AND LOLO CREEKS.

Lolo Creek heads near Rocky Ridge between the Lochsa and the North Fork, and after a tortuous course empties into the main Clearwater at Greers Ferry, a few miles above the mouth of Oro Fino Creek. In its upper course it is joined by Musselshell Creek, which heads in the same vicinity. The latter creek has been mined all the way, although no extraordinary richness is reported. Lolo Creek has been washed for gold in places, but ordinarily contains too many bowlders. The gold, like that of Pierce, is fine in size but of low grade, varying in value from $17 to $15 per ounce. A number of quartz veins are reported from the head of these two creeks, and the district may be considered as the southeasterly extension of the gold-bearing area of Pierce and the Mascot Hills. A prospect called the Pioneer was worked in 1899 and is situated on the low ridges between Musselshell and Lolo creeks, 10 miles east of Weippe. The vein strikes N. 70° E. and dips 85° S.

DEPOSITS BETWEEN CLEARWATER AND SNAKE RIVERS.

In the plateau country extending between Clearwater and Snake rivers the Columbia River lava covers nearly the whole area, though bed rock is occasionally exposed in the deep cuts of the canyons or in points protruding through the lava. No placer mines of importance have been worked in this area. The bottom gravels and bars of Salmon River and of Snake River contain gold, however, and these have been worked to some extent. Along Salmon River, especially where the gold is less fine than along the Snake, placer operations have been carried on in different places during the last few years. The aggregate yield is, however, small.

Near Harpster and Mount Idaho.—Many small quartz veins have been located and partly developed along the South Fork of the Clearwater near Harpster. None of them have, however, proved rich. The rock inclosing them consists of black slate, diorite, and amphibolite. Some miles above Harpster, along the same river and only a few miles east of Mount Idaho, a few veins have been discovered and were prospected in 1899. These veins form a silicified and mineralized streak in greenstone-schists almost at the river level and on the west side of the stream. The strike is northeasterly and the dip 60° SE. The main tunnel shows principally an altered greenstone containing much pyrite.

There are occasional bunches of quartz containing pyrite and chalcopyrite and inclosed in greenstone-schists. Good assays and free gold are reported to have been obtained from the Dewey, which was the main prospect worked at the time of visit. The developments chiefly consisted of a 50-foot tunnel.

Since 1899 a considerable amount of work has been done on these prospects and a great deal of ore has been shipped. The prospects near the river have been united as the Dewey Consolidated Mining and Smelting Company, and up to the present time the development work (tunnels, shafts, raises, and winzes) aggregates 3,000 feet. Nearly 200 tons of rich ore were shipped to smelters during 1900, yielding net $13,000, according to treasurer's report. Mr. Otto Abeling has made a report on the property in 1900 from which it appears that there are four parallel veins, striking N. 28° E. and dipping 75°. On the two outside veins, the Waverly and the West veins, but little work has been done, while the principal developments have been effected on the Dewey and the St. Patrick. The width of the veins is from 23 to 40 feet. The whole distance between the east wall of the Dewey and the west wall of St. Patrick is said to be 180 feet, within which distance all assays show some value. As stated above, the rock is a roughly schistose greenstone and the veins are about parallel to the schistosity. The ore consists of silicified and pyritic greenstone containing streaks and veinlets of quartz. The immediate outcrops of this rock were rather poor, showing little copper and but few dollars in gold. Tunnels driven on both veins soon struck a number of streaks of shipping ore very rich in gold and greater bodies of lower-grade material, both classes containing chalcopyrite in varying but not large amounts. Very little of the gold is free. On the Dewey vein more copper ores were found than on the St. Patrick. A small shoot of massive pyritic ore 3 feet wide yielded 3.4 per cent copper and $5 in gold. In another place a sample across 4 feet yielded 3.1 per cent copper, 12.7 ounces silver, and 4.38 ounces gold, according to Mr. Abeling, who also estimates the ore in sight as 34,650 tons with a value of $361,200.

Higher up on the hill, west of the Dewey, is the similar Evergreen property from which considerable shipments of smelting ore were reported in 1901.

In general character these deposits differ from the ordinary type of gold quartz veins common in this part of the country. They show a certain similarity to the Bully Hill deposits of Shasta County, Cal., and in both cases a certain amount of secondary concentration has probably been active.

Cottonwood Buttes.—The area of old rocks which protrude as low hills above the general surface of the Columbia River lava, a few miles north of Cottonwood on the Camas Prairie, contain several veins of quartz which have been prospected on a small scale. The veins strike north and south and are nearly vertical; the slate bed rock being 80 feet above river level and the top of the sandy gravel 300 feet above the same. This bar was hydraulicked in 1897 by the Victor Mining Company, of Spokane. The pay is concentrated in a thin layer of cemented gravel on the bed rock.

A big gravel bar 200 feet high is situated higher up on the west side opposite Carver's ranch. The limestone bed rock is only a few feet above the river and on it rests cemented gravel, containing very coarse gold of local origin. This deposit has been mined by drifting along the bed rock. Another large bar with much sand lies at a bend of the river a little north of Fiddle Creek. Still another high bar on which some placer mining has been done is situated on the south side of the river a few miles above the great bend at Salmon Point. Above this point there are only smaller low bars but the sands of these contain fine gold everywhere.

COEUR D'ALENE MOUNTAINS.

What little is known about this subject, really outside of the limits of this reconnaissance, is given below. For notes on the geology see page 81.

GOLD DEPOSITS.

The Coeur d'Alene Mountains are not rich in known gold deposits. Placer mines of moderate richness have been worked in the Moose Creek diggings on a branch of the North Fork of the Clearwater, a short distance west of the Montana-Idaho line. Minor deposits have also been worked at the head of the Middle Fork of St. Josephs River and on the Montana side near the head of Cedar Creek halfway between Mullan Pass and Missoula.

The most important deposits, placers as well as quartz veins, are situated at Murray and Delta on the North Fork of the Coeur d'Alene River, 15 miles north of the lead-mining district.

LEAD-SILVER VEINS.

To this class belong the celebrated deposits near Wardner, Wallace, and Mullan on the Coeur d'Alene River,[a] which are estimated to have produced about $60,000,000 of lead and silver since their discovery fifteen years ago. The lowest profitable percentage of lead in the mined ore is said to be about 6 per cent. The ores are subjected to careful concentration in large dressing works.

The deposits are clearly defined fissure veins cutting fine-grained greenish quartzites and quartzitic slates of doubtful (though probably pre-Cambrian) age. The principal ores are galena and zincblende, but there is also much finely distributed pyrite. Chalcopyrite is ordinarily absent. These are practically the only metallic minerals, and recur in all the deposits. The principal gangue mineral is siderite, accompanied by minor quantities of quartz and barite. Fluorite is absent. The fissures along which the ore bodies appear are well defined, and sometimes continuous for one or more miles. The ore bodies do not show much clearly defined crustification or other evidence of having been deposited in open space. The siderite appears always as an undoubted product of replacement, while many veinlets of quartz have in part resulted from the filling of open small fissures. Evidences of gradual transitions from ore to country rock are abundant, and are especially prominent in the mines carrying low-grade ore, as, for instance, in the Helena and Frisco. In the exposures underground, as well as in the specimens and thin sections, the evidence of replacement is complete and positive.

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[a] For a brief description of these mines, including technical features, see J. R. Finlay, Trans. Am. Inst. Min. Eng., February and May, 1902.

The greenish-gray fine-grained quartzite which constitutes the prevailing country rock contains no sulphides when fresh. It is composed of small, rounded, or subangular quartz grains, closely packed—often, indeed, jointing closely, as in a normal quartzite. Usually, however, a little sericite, in bunches of small fibers, is present as cementing material between the grains. There are few other minerals, exept a little feldspar in clastic grains, small prisms of tourmaline, and some grains of calcite. Near the veins minute specks of siderite, zincblende, pyrite, and galena appear in this quartzite; and these scattered grains gradually merge into bodies of merchantable ore. The thin sections show how the rock near the veins is filled with small grains of branching and irregular form, which consist of siderite, developed by attack first upon the groundmass and then upon the grains of clastic quartz. Accompanying the siderite are small grains of zincblende, cubes of pyrite and irregularly wiry masses of galena. All these sulphides appear not only in or near the siderite, but also in the cementing sericite, and in the apparently perfectly fresh quartz grains.

At a more advanced stage these areas of siderite extend until they join, and thus completely replace the rock. In the resulting ore lie scattered many small quartz grains, representing remnants of the clastic constituents of the quartzite. Occasionally larger masses of zincblende appear to form directly in the quartzite by metasomatic replacement of the quartz. The sericite in the quartz then disappears, though once in a while small foils of it may be detected. During the transition stage, seams and narrow veinlets in the altering rock are filled with sericite, apparently segregated there, when driven out from the main mass. In other specimens from the Helena and Frisco mine, the replacing siderite has a strong tendency to idiomorphic development. Imperfect rhombohedral forms are often seen, sometimes cutting straight across the clastic grains. Certain specimens from the Bunker Hill and Sullivan mine show quartzose grayish masses of irregular outline, and apparently merging gradually into the normal greenish quartzite. These quartzose masses consist of very irregular interlocking grains of quartz, not in the least similar to the quartz usually deposited by processes of filling, but having every appearance of resulting from the silicification of the quartzite. This silicified portion contains irregular grains of pyrite, galena, and brown zincblende, with a very little siderite.

The process, as outlined, is remarkable, as involving a metasomatic replacement of quartz by siderite, pyrite, galena, and zincblende, and is the only clearly defined occurrence of this kind of which I am aware.

Coming from the west the first deposits are found near the town of Wardner. The Bunker Hill lode is here the principal source of production of the Wardner district, estimated by Mr. J. R. Finlay to be $17,500,000. This remarkable vein system is continuous for 2 or 3 miles; its principal feature is a well-defined fault plane contained in quartzite and striking N. 42° W., the dip being 38° SW. The ore forms irregular masses above this fault plane or "foot wall." The mines are worked by tunnels, a deepest level being recently reached by a long 8 by 9 foot tunnel from near the Coeur d'Alene River, striking the veins 700 feet below the previously lowest tunnel level on the Bunker Hill and Sullivan mines. The croppings along the foot wall is indicated by a heavy iron cap stoped 50 feet wide at the surface. The ore is mainly galena, with a little pyrite and blende; the concentrates carry about 25 ounces of silver. There is practically no arsenic, antimony, or gold. Some galena appeared in the croppings, but also much cerussite in beautiful bunches and this secondary mineral continues in places as far as 200 feet below the surface.

Although the foot wall is so clearly defined by a fault plane, accompanied by a few inches of clayey gouge, the hanging wall of the ore bodies is extremely ill defined and in many places the mineralization simply fades out gradually. Some of the ore shoots lie on the foot wall, but others reach out as much as 200 feet horizontally from this plane. Some of the masses of galena, instead of strictly following the course of the foot wall, may locally follow a stratification plane and then jump back in offsets so as to preserve the general parallelism with the wall. The thickness of the ore bodies is as great as 90 feet; within the pay shoots the galena occurs irregularly; there are some massive bodies as much as 10 feet thick, which may change their outlines rapidly and irregularly and which are sometimes separated by horizontal joint planes from the barren quartzite. Most commonly, in the poorer ores, the galena occurs as small and very irregular seams associated with some quartz and siderite. The greatest ore body in the Bunker Hill and Sullivan vein had a maximum thickness of 90 feet, was several hundred feet long, and extended across a vertical distance of 170 feet. Its ore averaged 25 per cent lead. The ore stopped against a local hanging wall which lower down joined the principal foot wall.

Near Gem and Burke, 10 miles farther up the river and near a granite boss which here is intruded into the steeply dipping quartzites and clay slates, is another important vein system, generally called the "Canyon Creek lodes." The production of this system, which include such important mines as the Helena-Frisco, Tiger-Poorman, Mammoth Standard, Morning, You Like, and others, is estimated as $42,500,000 (J. R. Finlay). One system of vein strikes from Ninemile Creek across to Gem in an east-southeast direction, and thence across toward Mullan. Two parallel systems are found 2 and 4 miles north of Gem. The veins of the "Canyon Creek lodes" are simpler in structure than the Wardner deposits, but like those are typical replacement veins along shear zones of greater or smaller width.

The Helena-Frisco, a representative mine, produces about 600 tons of ore per day, which is concentrated in proportions of 9 to 1, yielding 50 to 70 tons of concentrates. The mine is opened by a shaft 1,800 feet deep. The country rock is a fine-grained greenish-gray quartzite. The vein which cuts the quartzite in strike and dip has a course of N. 80° W., and a variable southwest dip averaging 70°, and gradually straightening on lower levels. The ore averages 10 to 12 feet in width, and is taken out uniformly. The foot wall is very poorly defined; the hanging wall is also often indistinct, though usually roughly indicated. Sometimes every indication of geometrical walls is absent. The rock is hard and compact, even within the walls. Within the width of 12 feet are irregular streaks of fine-grained steely galena and blende, occasionally a couple of feet thick. Pyrite, and in places chalcopyrite, are sparingly represented. The gangue is finely divided siderite and a little quartz, the latter in narrow and irregular seams. The vein is clearly the result of replacement of quartzite by galena, zinc blende, and siderite, along tight fault planes. The vein system of which the Helena-Frisco forms a part continues for 6 miles and is faulted at several places by later fissures striking north-northeast.

The Morning and You Like are situated on the eastern end of this vein system, high up on the hill above Mullan. A tunnel 9,000 feet long and 900 feet below the working tunnel used in 1899 is projected to tap the vein from the mill level. The ore shoots, which are said to be strong, are 600 to 700 feet in length and 10 to 40 feet in width. The present capacity of this group is 700 tons of ore per twenty-four hours.

LIGNITE.

Coal of a lignitic character has been found in two widely distant parts of the area under examination. In neither case are the developments extensive enough to assure their commercial importance. At the head of the South Fork of Bitterroot River lignite has been found on Coal Creek, a small tributary from the west which enters the South Fork 10 miles above the mouth of the West or Nez Perce Fork. The deposit is connected with rhyolite, and appears, in fact, interbedded together with clays and sands in the upper part of the rhyolitic flows. Mr. J. B. Leiberg[a] states that the deposit occupies an area of about 500 acres, and that two seams have been discovered, the upper one with a thickness of 12 feet, while the extent of the lower is unkown. Coal Creek was visited by Mr. G. W. Stose, who reports that the rhyolite exposed in the bottom of the canyon continues practically all the way up to an elevation of 1,000 feet above the main stream. Two tunnels, 50 feet apart and at slightly different levels, the upper one boarded up, are the only developments. The coal seam was only partly exposed; 2½ feet of coal were seen, with a 3-inch seam of clay in the middle. The dip of the strata seems to be 22°. The roof of the coal consists of a clay full of vegetable matter, such as fern-like leaves, grasses, etc. Above this clay follows a hard and compact rhyolite tuff. The extent of the coal lands is problematic, and I am unable to say whether Mr. Leiberg's estimate is correct. At any rate, it is clear that the extent of the territory underlain by coal is small, and the well-known uncertainty of thickness and quality in other fields similar to this make predictions of doubtful value. A sample of the coal was analyzed by Dr. W. F. Hillebrand, with the following result:

Analysis of coal from near head of South Fork of the Bitterroot River.

	I.	II.
Moisture at 105°	7.21	7.21
Volatile combustibles	56.09	41.84
Fixed carbon	27.09	37.61
Ash	9.61	13.34
	100.00	100.00

The first column represents the composition as usually determined, the ash being found in the same portion as the volatile combustibles and fixed carbon. But the coal sparks enormously, and much ash and fixed carbon are ejected with the volatile combustibles.

The second column gives the true ash contents and the corrected volatile combustibles and fixed carbon, calculated on the assumption that the ratio of fixed carbon to ash in the ejected matter is the same as that in the coke of I. The coke is thoroughly sandy. The ash is pale buff colored.

The coal is black in color, and crumbles easily on exposure to the air. The analysis shows it to be a lignite of very fair quality, approaching a bituminous coal in composition. From its association with the rhyolite, the conclusion is strong that it is probably of Miocene age. A little lignite is reported to have been found in the upper area of rhyolite, 10 miles higher up on the South Fork, where a similar succession of rhyolitic flows and tuffs is exposed.

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[a] Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 5, 1898, p. 265.

The only other known occurrence is that on the west side of the Clearwater Mountains in the canyon of the Clearwater River. This coal, which occurs in a series of sedimentary beds interstratified with the Columbia River lava, has been described by Prof. I. C. Russell.[a] Professor Russell states that three seams of lignite from 2 to 20 inches in thickness and separated by a few feet of sandstone have been found half mile below Oro Fino on the south side of Clearwater River and at an elevation of about 200 feet above the same. The exposed beds are believed to be part of a landslide, and the true position of the beds is suggested to be 500 feet higher. Lignite is reported to occur at several localities on Oro Fino Creek (all of it probably belonging to approximately the same bed) within a distance of several miles in the middle portion of its course. In sec. 12, T. 36 N., R. 4 W. an exposure of this kind was examined by Professor Russell, who found 20 inches of lignite embedded in sandstone and clay. In another place near this exposure a shaft has exposed 27 inches of lignite. Here again landslides are believed to have occurred, and the true position should be looked for at an elevation of between 400 and 600 feet above the creek. The lignite-bearing rocks no doubt underlie a wide extent of the adjacent plateaus.

Similar exposures are also reported from several places in Little Canyon to the south of Oro Fino and on the west side of the river. At the place which was examined by Professor Russell no lignite but only carbonaceous shales were observed.

MINERAL SPRINGS.

A limited number of generally hot mineral springs are scattered over the area examined without special regularity and without showing any connection with lines of structure or volcanic flows. Beginning on the north, hot springs are found at the head of Lolo Fork and about 6 miles north of Lolo Pass. These springs, which yield a weak mineral water of high temperature and are of sufficient volume to supply a bathing establishment, break through granite not far from the contact with the sedimentary series. Going over to the Clearwater side, hot springs of similar nature are found at Jerry Johnson's on the Lochsa Fork at an elevation of 3,300 feet. They issue at different places a short distance below Warm Springs Creek and on the north side of the river. No hot springs are known to exist along the foot of the Bitterroot Range, but in the eastern foothills, about 12 miles southeast of Hamilton, hot waters issue at the place known as Weeping Child Hot Springs.

No hot springs are known on the South Fork of the Bitterroot River, but a cold soda spring occurs on a branch of the West or Nez Perce Fork of the Bitterroot

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[a] Water-Sup. and Irr. Paper No. 54, U. S. Geol. Survey, 1901, p. 122.

Range for a distance of 60 miles from north to south. Isolated high parts of the Clearwater Mountains were likewise centers of local glaciation. The lower limit of the glaciated areas is an elevation of 7,000 feet, though ice tongues on both sides of the mountains reached down to elevation of 4,000 feet.

The valuable minerals contained in this area are chiefly confined to the western slope of the Clearwater Mountains. The gold deposits are the most important, and occur as fissure veins and gravels. At the foot of the Bitterroot Mountains, about 12 miles north of Hamilton, Mont., is the remarkable Curlew mine, where a body of galena was found on a fissure having limestone and quartzite as its foot wall and the gravels of the Bitterroot Valley as hanging wall. On the upper South Fork of Bitterroot River prospects of copper, silver, and silver-lead ores have been worked. Hughes Creek, in the same vicinity, contains gold-bearing gravels which have been worked for many years.

Elk City, founded in 1862, is one of the centers of the gold-mining industry on the west slope. Gold to the value of several million dollars was extracted here from late Tertiary bench gravels, and placer mining is still prosecuted on a small scale. Quartz veins have also been recently opened in this old mining district. The well-defined quartz veins of Buffalo Hump, discovered in 1897, are actively worked, though not as yet on a very large scale. These deposits occur in granitic rocks, accompanied by contact metamorphic slates.

Florence, located 40 miles southwest of Elk City, is another of the old placer camps, discovered about 1861. The gravels were very rich, and the camp has yielded gold to the value of many million dollars. At present a few placers and quartz mines are worked there also. The bed rock is granite.

Pierce, on Oro Fino Creek, about 50 miles north-northwest of Elk City, also a well-known placer camp, was founded in 1861, and its gravels have been continuously worked since then. The present yield from these placers is probably about $30,000 per annum. The gravels occur as creek alluvium and as benches up to 500 feet above the present drainage level. Quartz veins have also been found near Pierce, and many of them are being worked on a small scale. The veins occur in gneisses and schists.

The total production of this gold-bearing region, extending at the western foot of the Clearwater Mountains, from the North Fork of the Clearwater to Salmon River, is at the present time probably about $160,000 per annum.

Coal of fair quality has been found on the upper South Fork of the Bitterroot Valley, and the beds are here associated with rhyolite. The developments have not as yet shown the extent of this occurrence.

Lignite of fair quality also occurs on Oro Fino Creek below Pierce, but the beds are probably not thick enough to allow profitable working.

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Professional Paper No. 28

Series { D, Petrography and Mineralogy, 27
E, Chemistry and Physics, 41

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

# THE
# SUPERIOR ANALYSES OF IGNEOUS ROCKS
FROM
ROTH'S TABELLEN, 1869 TO 1884

ARRANGED ACCORDING TO THE QUANTITATIVE SYSTEM OF CLASSIFICATION

BY

HENRY STEPHENS WASHINGTON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1904

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LETTER OF TRANSMITTAL.

Department of the Interior,
United States Geological Survey,
Washington, D. C., March 5, 1904.

Sir: I have the honor to transmit to you a manuscript entitled "Superior Analyses of Igneous Rocks from Roth's Tabellen, 1869 to 1884," by Henry Stephens Washington, with the recommendation that it be published by the Survey as a Professional Paper. This compilation brings together all the quantitative analyses of igneous rocks made prior to 1884 that possess a sufficient degree of excellence to render them of value to the petrographer of the present day. The analyses of this collection are arranged according to the method used by the author in his tables of analyses published since the last edition of Roth's tables, issued by the Survey as Professional Paper No. 14. The two compilations thus bring into uniform shape for ready reference all the "superior" analyses of igneous rocks published up to 1901. In view of the long recognized value to geologists and petrographers of the compilations by Justus Roth, it is clear that the tables prepared by Doctor Washington, embracing all the analyses of high grade and accompanied by critical discussion, must be of still greater benefit to all students of igneous rocks.

Very respectfully,

Whitman Cross,
Geologist in Charge, Section of Petrology.

Dr. C. W. Hayes,
Geologist in Charge of Geology.

alkalies or other constituents are determined by difference from 100 per cent, when the alkalies have not been separated, or when any constituent of the first importance has not been determined, etc.

To express the various ratings of equal value the following terms are employed: Excellent or first rate, good or second rate, fair or third rate, poor or fourth rate, and bad or fifth rate. Their meanings, in terms of the symbols chosen, are seen in the subjoined table, ratings of the same value falling on the same horizontal line:

Scheme for rating rock analyses.

First rate	A1	....	....	....	Excellent..	Superior.
Second rate	A2	B1	....	....	Good......	
Third rate	A3	B2	C1	....	Fair.......	
Fourth rate	A4	B3	C2	D1	Poor	Inferior.
Fifth rate	....	B4	C3	D2	Bad	
	....	....	C4	D3		
	....	....	....	D4		

The general lines along which the selection of analyses for the present work was made were those laid down in Professional Paper No. 14 for the classification of the tables into two parts, one containing the "superior" analyses, and the other containing the "inferior" ones. With few exceptions there are to be found in the present collection only those analyses which logically fall in the first class.

In the first place, all the analyses found in Roth's Tabellen of 1861 were rejected. By far the greater number of these are "inferior" in any case, as, apart from bad summations and other obvious inaccuracies, only about two dozen show separate determinations of the iron oxides. Furthermore, regard being had to their very early date and the uncertain methods of chemical analysis obtaining at that period, even what are apparently the best of them must be considered as merely more or less rough approximations, chiefly of historical interest, and of little or no use in present-day investigations. On taking up Roth's collections, published respectively in 1869, 1873, 1879, and 1884, all analyses of crystalline schists and other metamorphic rocks were excluded. The many analyses of avowedly or evidently decomposed igneous rocks were also rejected. Partial analyses, those of groundmass, or those of rocks from which it is stated that some of the mineral constituents (as magnetite) had been removed prior to analysis, as well as those of portions soluble and insoluble in HCl, were also passed over. In a number of cases, however, when otherwise deemed to be of superior quality, analyses representing the bulk composition of rocks, calculated from the analyses of the soluble and insoluble portions, were admitted, though such can not be held to have the weight of a complete rock analysis, made directly.

A few of the analyses appearing in Roth's Tabellen of 1884 were also published in Professional Paper No. 14. These have been included in the present work, with a remark to the effect that they are also to be found in the other paper.

Although it has been impossible to examine thoroughly the vast mass of literature published prior to 1884, yet several analyses have been found which are not given by Roth. All of those so found are, however, of inferior quality, either because the iron oxides were not separately determined or for other reasons, so that in fact no analysis published prior to 1884 and not collected by Roth is present in this work.

COMPLETENESS OF ANALYSES.

Turning from the analyses excluded on the general grounds noted above, we come to those rejected on account of the incompleteness or the inaccuracy of the analysis. By far the most numerous of this group are those in which the iron oxides have not been determined separately. As has been already explained,[a] if the sum of iron oxides exceeds 1 or 2 per cent and they are not separately determined, it is impossible to use an analysis in the calculation of either the norm (and hence in the determination of the classificatory position of the rock) or the mode or actual mineral composition, unless totally arbitrary assumptions are made which may or may not be in accordance with fact. A calculation involving such assumptions will have little or no value. This ground for exclusion is, of course, most seriously felt in the more femic (basic) rocks, since among those which are obviously of the persalane class, especially in the quaric orders, the amount of iron oxides is usually so small as to render practically negligible the error due to their nonseparation and the assumption in the calculation that they are present as FeO. A considerable number of these last will be found in the following pages. Such analyses were similarly treated in Professional Paper No. 14.

Roth's Tabellen also contain some analyses in which K_2O, Na_2O, MgO, or CaO are not determined, as well as a few in which the alumina and iron oxides are not separated. These, of course, are omitted.

Analyses are numerous, in fact they constitute the great majority of those in question, in which TiO_2 or P_2O_5, or both, have not been determined. This affects the apparent amount of alumina, rendering it too high, and among the more femic rocks, especially those of the salfemane class, this defect is apt to lead to serious error in the assigned classificatory position of the rock. All such analyses, however, if complete as to the main constituents, have been admitted to the present work, and rated 3 as regards completeness, according to the lines previously laid down. It must be repeated[a] here that the assigned classificatory positions of rocks represented by such incomplete analyses are to be regarded in general as provisional, and subject to change when complete analyses are available.

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[a] Washington, H. S., Prof. Paper U. S. Geol. Survey No. 14, p. 43.

In this connection attention may be called to the fact that for the proper calculation of the minor divisions, grad, subgrad, and their sections, in Classes II and III, of the Quantitative system, the determination of TiO_2 and P_2O_5, is absolutely necessary. This arises from the following facts: The P_2O_5 determines the amount of apatite, and hence the ratio $\frac{P,\ O,\ M}{A}$, and also gives the correct amount of CaO'' which enters normative diopside or wollastonite and which affects the amount of MgO and FeO for normative hypersthene and olivine. The TiO_2 indicates the amount of ilmenite, and hence its determination is essential for a correct statement of the ratio $\frac{P,\ O}{M}$, which determines the grad, and also affects the amount of FeO available for diopside, hypersthene, and olivine.

It is true that these substances are present usually in comparatively small amounts, most frequently in quantities less than 1 per cent. But as the minor divisions, grad, subgrad, and their sections in the classes named, are based on the mineralogical and chemical characters of the subordinate normative minerals, small amounts will assume here an importance which they do not usually have when dealing with the major divisions, order, rang, and subrang.

It will also be evident that, in dealing with Classes IV and V, the determination of these constituents is necessary for the proper computation of the major divisions, order, rang, and subrang.

ACCURACY OF ANALYTICAL METHODS.

Turning to the other factor involved in the quality of an analysis, its accuracy, we are confronted with the fact in this case that at the time the great majority of the analyses found in Roth's Tabellen were made the methods and means of analysis were inferior to those of the present day. New methods have been devised to eliminate serious constant errors discovered in many of the older methods, and these have been modified or new ones adopted which do not involve such errors, while apparatus has been improved and chemicals have been purified, all these changed conditions leading to greater accuracy and expedition in carrying out the processes involved. This general aspect of all the older work is of such serious importance that the exacting petrographer who demands data of a high degree of excellence by Iddings in a recent work.[a] This method, elaborated beyond the form used by Iddings, may conveniently be described here, for the benefit of those petrographers who may desire to use the proposed classification.

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[a] Washington, H. S., Prof. Paper U. S. Geol. Survey No. 14, p. 45.

It consists of stating numerically the several hierarchical divisions in which the magma falls. Thus the name monzonose may be replaced by the symbol II.5.2.3. Here II indicates that the magma falls in Class II (dosalane), 5 that the order is the fifth (perfelic), 2 that the rang is the second (domalkalic), and 3 that the subrang is the third (sodipotassic).

In the case of a threefold division, as that of a docalcic rang into three subrangs, a prepotassic, a sodipotassic, and a presodic, we have heretofore designated these as the first, second, and third, or as 1, 2, and 3, respectively.[b] We find in practice, however, that this procedure is liable to give rise to serious misunderstanding, since, for example, in one case a 3 which occupies the subrang position in the symbol will mean that the subrang is sodipotassic, and in another that it is presodic, great attention being necessary to keep clear in mind whether the rang is subject to a fivefold or to a threefold division.

We have therefore somewhat modified our original plan, and, keeping to the use of five numbers throughout,[c] propose to indicate the threefold character of a subdivision by combining the numerals of the first and second and of the fourth and fifth divisions, as is done in the classification, placing a comma between them. Thus the presodic subrang auvergnose of the docalcic rang auvergnase will be indicated by the symbol III.5.4.4,5. This may be expressed in words by using the phrase "fourth-fifth subrang." It is not necessary to explain that the numbers referring to orders will be those from 1 to 9.

Sections of any of the divisions may be indicated by the appropriate figures placed exponentially. Thus the subrang uvaldose will have the symbol $IV.2^3.1^2.2$. Subclasses and suborders, which will be used seldom, may be expressed by the use of the appropriate numeral inclosed in parentheses. Thus the symbol of kyschtymose would be $I(3^1).5.5.0.$, there being no subrang needed, as the rang is percalcic.

Grads and subgrads, with their sections, may be expressed in an exactly similar way, their indicative numerals following those of the major divisions, and being printed in *italics* for greater distinctiveness. Thus the full magmatic symbol of the typical monzonite of Monzoni (monzonote)[d] would be $II.5.2.3.\mathit{1},\mathit{2}.\mathit{1},\mathit{2}^{1,2}$.

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[a] Iddings, J. P., Prof. Paper U. S. Geol. Survey No. 18, 1903, pp. 67 and 72.

[b] Cross, Iddings, Pirsson, Washington, op. cit., pp. 122, 137.

[c] An apparent exception is that of the orders in Classes I, II, and III, which number nine. The exception is apparent only, as the orders are really arranged in a series of two fivefold groups, joined by the fifth (perfelic) order, which is common to both. Cf. C. I. P. W., op. cit., p. 131.

[d] As has been pointed out by Milch (Centralblatt für Mineralogie, 1903, p. 691), there was a slight confusion in our statement of the position of this rock (C. I. P. W., op. cit., p. 176), owing to the substitution of a fivefold for a threefold division. The grad was given as the second, while it should be the first-second, and similarly with the subgrad. In the above symbol I have inserted the exponential figure for the section of subgrad, expressing the relation of [illegible] although strictly speaking it is not needed.

In the case of a transition rock, the numeral of the division near the border of which it falls may be written *before* the one expressing its exact position (to correspond with the nomenclature),[a] and connected with it by a hyphen. If the rock is transitional in several respects, the numeral of each of such divisions will have its appropriate hyphenated preceding numeral. Thus the magma of the leucitite of Capo di Bove, which is a vesuvose-albanose,[b] may be expressed by III–II.6.2.2, and that of the porphyrite of the Suldenferner,[c] which is an andose, but near the borders of harzose, tonalose, and shoshonose, may be written as II.4–5.4–3.4.

QUALITY OF ANALYSES AT DIFFERENT PERIODS.

It has already been remarked that the proportion of analyses of superior quality to be found in Roth's Tabellen is remarkably small. It may be of interest to examine this matter somewhat more in detail, especially as such an examination brings out very clearly the steady improvement in analytical work which has been in progress since the first tables were compiled by Roth. In the table below is given the number of analyses to be found in the various issues of Roth's Tabellen, omitting those of metamorphic rocks, of groundmass, and of portions soluble and insoluble in HCl. The number which has been admitted to the present work is also given in each case, as well as the percentage which each represents. For comparative purposes there are given below the corresponding figures for the analyses published from 1884 to 1900, taken from my previous work.

Number of analyses published in Roth's Tabellen, with number and percentage of superior analyses republished from that and other sources in Professional Papers Nos. 14 and 28.

	Total number of analyses.	Number of superior analyses in W. R. T.	Per cent of superior analyses in W. R. T.
R. T. 1861	616	0	0
R. T. 1869	744	67	9.01
R. T. 1873	232	24	10.38
R. T. 1879	422	69	16.35
R. T. 1884	408	88	21.57
	2,422	248	10.24
W. T. 1900	2,881	1,864	64.70
	5,303	2,112	39.83

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[a] Cf. C. I. P.W., op. cit., pp. 166, 175.

[b] W. T., p. 202.

[c] W. R. T., No. 11, andose, p. 46.

THE SUPERIOR ANALYSES OF IGNEOUS ROCKS FROM ROTH'S TABELLEN, 1869 TO 1884.

By Henry S. Washington.

INTRODUCTION.

In Professional Paper No. 14[a] there were collected the chemical analyses of igneous rocks published from 1884 to 1900, inclusive, arranged according to the quantitative system of classification recently proposed by Cross, Iddings, Pirsson, and Washington[b]. In order to supplement this work it has appeared advisable to select the more reliable and complete of the earlier analyses collected by Justus Roth[c] and arrange them also in the same manner for publication. Petrographers would thus have available for use according to the new system almost the entire body of chemical work of real value on igneous rocks, the exceptions being a few analyses published prior to 1900 which may have been overlooked by both Roth and myself. The two collections would form a foundation as broad as possible for future research and discussion.

I must express my sense of obligation to the United States Geological Survey for publishing the present collection of analyses, and my thanks to my colleagues in the new system of classification for their friendly advice and assistance.

BASIS FOR THE SELECTION OF ANALYSES.

GROUNDS FOR THE REJECTION OF CERTAIN CLASSES OF ANALYSES.

In view of the time at which the majority of the analyses collected by Roth were made it is of course natural that a very large proportion of them do not come up to modern standards and must be rejected as unfit for use in the quantitative classification of rocks. A critical examination shows, in fact, that, adopting the criteria used in the earlier tables,[a] the proportion of "superior" analyses is in reality exceedingly small. The numerical data will be discussed on a subsequent page.

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[a] Washington, H. S., Chemical analyses of igneous rocks published from 1884 to 1900: Prof. Paper U. S. Geol. Survey No. 14, 1903. This will be referred to by the abbreviation W. T.

[b] Quantitative Classification of Igneous Rocks, Chicago, 1903.

[c] Roth, Justus, Die Gesteins-Analysen, Berlin, 1861. Roth, Justus, Beiträge zur Petrographie der plutonischen Gesteine: Abhandl. Kön. Akad. Wiss. Berlin, 1869, 1873, 1879, and 1884. These will be referred to as Roth's Tabellen (R. T.), with the appropriate date.

The criteria according to which the "ratings" or indication of the relative value of the analyses have been assigned by me may be summarized from Professional Paper No. 14 (pp. 39–41).

The general idea is that followed by Dun and Bradstreet in assigning credit ratings to commercial houses. The factors on which the value of an analysis depends are two—its accuracy and its completeness—and, within restricted limits, each of these compensates for the other to a certain extent. The degree of accuracy is expressed by the letters A, B, C, D, and the degree of completeness by the figures 1, 2, 3, 4, in combinations of a letter and a figure, the former preceding.

A is used when the analysis gives evidence of a high degree of accuracy—that is, when it corresponds well with the mode (actual mineral composition), and when the summation is between the limits 99.50 and 100.75. B is assigned when the analysis and the mode correspond, and when the summation is between 99.50 and 99.00, or between 100.75 and 101.25. C applies when the analysis corresponds fairly well with the mode, or when the sum is between 99.00 and 98.50 or between 101.25 and 101.75. D is to be used when the analysis varies decidedly from the mode in any important particular, or when the sum is below 98.50 or above 101.75.

1 is assigned when the analysis is perfectly complete or nearly so, as when, in addition to all the main constituents and those of secondary importance, there are determined ZrO_2, Cr_2O_3, NiO, BaO, and the like, or several of these. The iron oxides should be separately determined in all cases to have this figure apply. 2 will be used when all the main constituents, including both oxides of iron, have been determined, as well as the constituents of secondary importance, including especially TiO_2 and P_2O_5, but when the minor constituents, as ZrO_2, etc., have not been determined. 2 will also be applied to the analysis of salic rocks in which the iron oxides are present in small amount, but have not been separated, and which are otherwise so complete as to fall under 1. 3 applies to analyses in which the main constituents, including both oxides of iron, have been determined, but not TiO_2, P_2O_5, Cl, etc. (or the minor constituents), unless minerals rich in these are so abundant as to make their estimation of the same importance as that of the main constituents. 3 also includes analyses of rocks which are very low in iron oxides when these have not been separated, but which are otherwise complete according to the requirements of 2. 4 is assigned when, with the exceptions noted above, the iron oxides have not been separated, when the

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[a] Washington, H. S., Prof. Paper U. S. Geol. Survey No. 14, p. 28.

alkalies or other constituents are determined by difference from 100 per cent, when the alkalies have not been separated, or when any constituent of the first importance has not been determined, etc.

To express the various ratings of equal value the following terms are employed: Excellent or first rate, good or second rate, fair or third rate, poor or fourth rate, and bad or fifth rate. Their meanings, in terms of the symbols chosen, are seen in the subjoined table, ratings of the same value falling on the same horizontal line:

Scheme for rating rock analyses.

First rate	A1				Excellent	Superior.
Second rate	A2	B1			Good	
Third rate	A3	B2	C1		Fair	
Fourth rate	A4	B3	C2	D1	Poor	Inferior.
Fifth rate		B4	C3	D2	Bad	
			C4	D3		
				D4		

The general lines along which the selection of analyses for the present work was made were those laid down in Professional Paper No. 14 for the classification of the tables into two parts, one containing the "superior" analyses, and the other containing the "inferior" ones. With few exceptions there are to be found in the present collection only those analyses which logically fall in the first class.

In the first place, all the analyses found in Roth's Tabellen of 1861 were rejected. By far the greater number of these are "inferior" in any case, as, apart from bad summations and other obvious inaccuracies, only about two dozen show separate determinations of the iron oxides. Furthermore, regard being had to their very early date and the uncertain methods of chemical analysis obtaining at that period, even what are apparently the best of them must be considered as merely more or less rough approximations, chiefly of historical interest, and of little or no use in present-day investigations. On taking up Roth's collections, published respectively in 1869, 1873, 1879, and 1884, all analyses of crystalline schists and other metamorphic rocks were excluded. The many analyses of avowedly or evidently decomposed igneous rocks were also rejected. Partial analyses, those of groundmass, or those of rocks from which it is stated that some of the mineral constituents (as magnetite) had been removed prior to analysis, as well as those of portions soluble and insoluble in HCl, were also passed over. In a number of cases, however, when otherwise deemed to be of superior quality, analyses representing the bulk composition of rocks, calculated from the analyses of the soluble and insoluble portions, were admitted, analyses, however, if complete as to the main constituents, have been admitted to the present work, and rated 3 as regards completeness, according to the lines previously laid down. It must be repeated[a] here that the assigned classificatory positions of rocks represented by such incomplete analyses are to be regarded in general as provisional, and subject to change when complete analyses are available.

In this connection attention may be called to the fact that for the proper calculation of the minor divisions, grad, subgrad, and their sections, in Classes II and III, of the Quantitative system, the determination of TiO_2 and P_2O_5, is absolutely necessary. This arises from the following facts: The P_2O_5 determines the amount of apatite, and hence the ratio $\frac{P, O, M}{A}$, and also gives the correct amount of CaO'' which enters normative diopside or wollastonite and which affects the amount of MgO and FeO for normative hypersthene and olivine. The TiO_2 indicates the amount of ilmenite, and hence its determination is essential for a correct statement of the ratio $\frac{P, O}{M}$, which determines the grad, and also affects the amount of FeO available for diopside, hypersthene, and olivine.

It is true that these substances are present usually in comparatively small amounts, most frequently in quantities less than 1 per cent. But as the minor divisions, grad, subgrad, and their sections in the classes named, are based on the mineralogical and chemical characters of the subordinate normative minerals, small amounts will assume here an importance which they do not usually have when dealing with the major divisions, order, rang, and subrang.

It will also be evident that, in dealing with Classes IV and V, the determination of these constituents is necessary for the proper computation of the major divisions, order, rang, and subrang.

ACCURACY OF ANALYTICAL METHODS.

Turning to the other factor involved in the quality of an analysis, its accuracy, we are confronted with the fact in this case that at the time the great majority of the analyses found in Roth's Tabellen were made the methods and means of analysis were inferior to those of the present day. New methods have been devised to eliminate serious constant errors discovered in many of the older methods, and these have been modified or new ones adopted which do not involve such errors, while apparatus has been improved and chemicals have been purified, all these changed conditions leading to greater accuracy and expedition in carrying out the processes involved. This general aspect of all the older work is of such serious importance that the exacting petrographer who demands data of a high degree of excellence by Iddings in a recent work.[a] This method, elaborated beyond the form used by Iddings, may conveniently be described here, for the benefit of those petrographers who may desire to use the proposed classification.

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[a] Washington, H. S., Prof. Paper U. S. Geol. Survey No. 14, p. 45.

It consists of stating numerically the several hierarchical divisions in which the magma falls. Thus the name monzonose may be replaced by the symbol II.5.2.3. Here II indicates that the magma falls in Class II (dosalane), 5 that the order is the fifth (perfelic), 2 that the rang is the second (domalkalic), and 3 that the subrang is the third (sodipotassic).

In the case of a threefold division, as that of a docalcic rang into three subrangs, a prepotassic, a sodipotassic, and a presodic, we have heretofore designated these as the first, second, and third, or as 1, 2, and 3, respectively.[b] We find in practice, however, that this procedure is liable to give rise to serious misunderstanding, since, for example, in one case a 3 which occupies the subrang position in the symbol will mean that the subrang is sodipotassic, and in another that it is presodic, great attention being necessary to keep clear in mind whether the rang is subject to a fivefold or to a threefold division.

We have therefore somewhat modified our original plan, and, keeping to the use of five numbers throughout,[c] propose to indicate the threefold character of a subdivision by combining the numerals of the first and second and of the fourth and fifth divisions, as is done in the classification, placing a comma between them. Thus the presodic subrang auvergnose of the docalcic rang auvergnase will be indicated by the symbol III.5.4.4,5. This may be expressed in words by using the phrase "fourth-fifth subrang." It is not necessary to explain that the numbers referring to orders will be those from 1 to 9.

Sections of any of the divisions may be indicated by the appropriate figures placed exponentially. Thus the subrang uvaldose will have the symbol $\mathrm{IV}.2^{3}.1^{2}.2$. Subclasses and suborders, which will be used seldom, may be expressed by the use of the appropriate numeral inclosed in parentheses. Thus the symbol of kyschtymase would be $\mathrm{I}(3^{1}).5.5.0.$, there being no subrang needed, as the rang is percalcic.

Grads and subgrads, with their sections, may be expressed in an exactly similar way, their indicative numerals following those of the major divisions, and being printed in *italics* for greater distinctiveness. Thus the full magmatic symbol of the typical monzonite of Monzoni (monzonote)[d] would be $\mathrm{II}.5.2.3.\mathit{1},\mathit{2}.\mathit{1},\mathit{2}^{1,2}$.

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[a] Iddings, J. P., Prof. Paper U. S. Geol. Survey No. 18, 1903, pp. 67 and 72.

[b] Cross, Iddings, Pirsson, Washington, op. cit., pp. 122, 137.

[c] An apparent exception is that of the orders in Classes I, II, and III, which number nine. The exception is apparent only, as the orders are really arranged in a series of two fivefold groups, joined by the fifth (perfelic) order, which is common to both. Cf. C. I. P. W., op. cit., p. 131.

[d] As has been pointed out by Milch (Centralblatt für Mineralogie, 1903, p. 691), there was a slight confusion in our statement of the position of this rock (C. I. P. W., op. cit., p. 176), owing to the substitution of a fivefold for a threefold division. The grad was given as the second, while it should be the first-second, and similarly with the subgrad. In the above symbol I have inserted the exponential figure for the section of subgrad, expressing the relation of (Mg,Fe)O:CaO″, although strictly speaking it is not needed.

In the case of a transition rock, the numeral of the division near the border of which it falls may be written *before* the one expressing its exact position (to correspond with the nomenclature),[a] and connected with it by a hyphen. If the rock is transitional in several respects, the numeral of each of such divisions will have its appropriate hyphenated preceding numeral. Thus the magma of the leucitite of Capo di Bove, which is a vesuvose-albanose,[b] may be expressed by III–II.6.2.2, and that of the porphyrite of the Suldenferner,[c] which is an andose, but near the borders of harzose, tonalose, and shoshonose, may be written as II.4–5.4–3.4.

QUALITY OF ANALYSES AT DIFFERENT PERIODS.

It has already been remarked that the proportion of analyses of superior quality to be found in Roth's Tabellen is remarkably small. It may be of interest to examine this matter somewhat more in detail, especially as such an examination brings out very clearly the steady improvement in analytical work which has been in progress since the first tables were compiled by Roth. In the table below is given the number of analyses to be found in the various issues of Roth's Tabellen, omitting those of metamorphic rocks, of groundmass, and of portions soluble and insoluble in HCl. The number which has been admitted to the present work is also given in each case, as well as the percentage which each represents. For comparative purposes there are given below the corresponding figures for the analyses published from 1884 to 1900, taken from my previous work.

Number of analyses published in Roth's Tabellen, with number and percentage of superior analyses republished from that and other sources in Professional Papers Nos. 14 and 28.

	Total number of analyses.	Number of superior analyses in W. R. T.	Per cent of superior analyses in W. R. T.
R. T. 1861	616	0	0
R. T. 1869	744	67	9.01
R. T. 1873	232	24	10.38
R. T. 1879	422	69	16.35
R. T. 1884	408	88	21.57
	2,422	248	10.24
W. T. 1900	2,881	1,864	64.70
	5,303	2,112	39.83

[a] Cf. C. I. P. W., op. cit., pp. 166, 175.

[b] W. T., p. 202.

[c] W. R. T., No. 11, andose, p. 46.

Of the above table it must be said in the beginning that the figures for Roth's Tabellen and for Washington's Tables are not quite strictly commensurate. The figures in the second column represent, as far as Roth's Tabellen are concerned, only the analyses which have been admitted to the present work, and thus those of tuffs and of decomposed rocks are excluded, while in the figures for my tables such analyses are counted if of superior quality. Consequently the figures giving the percentages of superior analyses for Roth's Tabellen will be somewhat too low. This, however, is counterbalanced by the fact that a considerable number of analyses of quaric persalane rocks, in which the iron oxides have not been separated and which are consequently fourth rate, have been included in the figures given above for Roth, while all such have been omitted from the total showing the superior analyses published since 1884. As the table is of no great importance, and is intended only to show the general condition of affairs, it has not been thought worth while to adjust these discrepancies.

Perhaps the most obvious fact brought out by the figures above is the very poor, not to say bad, quality of the earlier work, as compared with that of to-day. The average of superior analyses represented by R. T., 1861 to 1884, is only 10.24, while for the seventeen years from 1884 to 1900 it is 64.70.

This great difference is due, as the table testifies most eloquently, to the steady improvement in the quality of analytical work from the beginning. The figures expressing the percentages of superior analyses rise steadily from 1861 to 1884, each being successively higher than the one preceding it. The great improvement shown between 1861 and 1869 is very largely due to the fact that the iron oxides were more often separately determined. After 1884 the improvement is still more rapid, the table showing an average of 64.70 of superior analyses between 1884 and 1900. This is very largely owing to the establishment of the laboratory of the United States Geological Survey in 1880 and its copious output, especially in late years, of rock analyses of the highest quality. Even this last ratio shows a percentage of which neither petrographers nor analytical chemists need be proud, but it is at any rate evidence of a decided change for the better, and, with the increasing emphasis which is being laid on this side of petrography, gives promise of an increasingly brighter future.

Hillebrand, Geikie,[a] and others have called attention to this contrast, but it would be well if every petrographer would consider the data for himself in order that he might fully realize the unsatisfactory character of the great body of analyses on which so much theoretical discussion has been based. He would then surely cast his influence for a higher grade of analytical work.

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[a] Geikie, Sir Archibald, Text-book of Geology, Vol. I, 1903, p. 116.

As to the absolute number of analyses, the table shows that there has been a steady increase, as was to have been expected. In about twenty years prior to 1861 there were made 616 analyses, or on an average about 30 analyses a year. During the twenty-three years from 1861 to 1884, 1,806 analyses were made, an annual average of 78.5, while in the seventeen years from 1884 to 1900 the much larger number of 2,881 analyses were made, or 169.4 a year.

LIST OF ABBREVIATIONS.

In the case of words etymologically alike, but in different languages, only the English form is given. The other abbreviations used will be self-explanatory.

REFERENCES.

A	American.
Abh	Abhandlung.
Ac	Academy, etc.
A. J. S	American Journal of Science (New Haven).
Ak	Akademie.
Arch	Archive.
Att	Atti.
B	Bulletin, etc.
B. B	Beilage Band.
Ber	Berichte.
Btr	Beiträge.
C. I. P. W	Cross, Iddings, Pirsson, Washington.
D	Deutsch.
Ds	Denkschrift.
Erdk	Erdkunde.
Erl	Erläuterung.
Finl	Finland.
Fr	France, Freunde.
G	Geology, etc.
Geog	Geognosie.
Ges	Gesellschaft.
Gest	Gesteine.
G. S	Geological Survey.
In. diss	Inaugural dissertation.
Ir	Irish.
It	Italian.
J	Journal.
Jb	Jahresbericht.
K	Kaiserlich.
L-A	Landes-Anstalt.
Mem	Memoir, etc.
N	New, etc.
Nat	Nature, etc.
Nf	Naturforscher.
Nh	Natural history.
N. J	Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie (Stuttgart).
N. J. B. B	Neues Jahrbuch, Beilage Band (Stuttgart).
Nk	Naturkunde.

ANALYSES.

ORDER 3. QUARFELIC. COLUMBARE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
SUBRANG 1. PERPOTASSIC.						
	Q 43.6 ns 1.6 or 46.2 di 0.7 ab 1.1 wo 1.3 mt 1.5 hm 5.0	Fork Hill, County Armagh, Ireland.	S. Haughton.	S. Haughton, J. G. Soc. Dubl. IX, p. 334, 1862. R. T. 1869, p. LII.	Felsite-porphyry.	Iron oxides? Alkalies?
SUBRANG 3. SODIPOTASSIC. ALASKOSE.						
	Q 39.7 hy 2.8 or 28.4 ab 26.2 an 2.2 C 0.2	Carrickburn, County Wexford, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac. XXIII, p. 615, 1859. R. T. 1869, p. LVIII.	Felsite.	
	Q 39.5 hy 3.2 or 28.4 mt 0.7 ab 21.0 hm 3.0 an 1.7 C 2.1	Pitt's Head, Caernarvonshire, Wales.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac. XXIII, p. 615, 1859. R. T. 1869, p. LVIII.	Felsite.	
	Q 38.6 hy 0.4 or 28.4 mt 0.5 ab 28.8 hm 1.6 an 1.7	Near Andlau, Vogesen.	L. van Werveke.	H. Rosenbusch, Steig. Schiefer, p. 384, 1877. R. T. 1879, p. XX.	Granophyre.	
	Q 36.7 hy 1.0 or 27.8 mt 1.5 ab 28.8 an 3.6 C 0.8	Kirneckthal, Vogesen.	L. van Werveke.	H. Rosenbusch, Steig. Schiefer, p. 383, 1877. R. T. 1879, p. XX.	Quartz-porphyry.	
	Q 41.5 hy 0.5 or 26.1 mt 1.4 ab 26.7 an 1.4 C 2.5	Tryberg Waterfall, Schwarzwald, Baden.	L. McCay.	G. H. Williams, N. J. B. B., II, p. 609, 1883. R. T. 1884, p. XVI.	Quartz-porphyry.	In W. T., p. 129. No. 27, alaskose
	Q 37.4 hy 2.6 or 28.9 ab 26.2 an 1.7 C 2.4	Schönberg, n. Waldheim, Saxony.	Lemberg.	Lemberg, Z. D. G. G., XXVIII, p. 597, 1875. R. T. 1879, p. XII.	Granite.	
	Q 36.1 hy 3.0 or 32.8 ab 22.0 an 3.3 C 1.7	Johanngeorgenstadt, Saxony.	Rube.	Scheerer, Festschrift, p. 180, 1866. R. T. 1869, p. XXXIV.	Granite.	
SUBRANG 4. DOSODIC. TAUROSE.						
	Q 56.0 hy 2.0 or 11.1 ab 26.2 an 1.7 C 0.2	Mte. Menone, Euganean Hills, Italy.	G. vom Rath.	G. vom Rath, Z. D. G. G., XVI, p. 516, 1864. R. T. 1869, p. XC.	Perlite.	
SUBRANG 5. PERSODIC. WESTPHALOSE.						
S 0.04 **Org** 0.07	Q 50.2 di 0.7 or 3.3 hy 0.6 ab 37.7 mt 1.9 an 3.3	Pasel, Lennegebiet, Westphalia.	Jacobs.	K. A. Lossen, Sb. Ges. Nf. Freunde, p. 178, 1883. R. T. 1884, p. XX.	Quartz-keratophyre.	In W. T., p. 131. No. 2, westphalose.
SUBRANG 1. PERPOTASSIC.						
	Q 39.1 hy 5.3 or 39.5 mt 1.2 ab 4.7 an 8.9 C 1.0	Lappinlax, Isl'd Hochland, Finland.	Lemberg.	Lemberg, Arch. Nk. Livl. IV, p. 189, 1867. R. T. 1869, p. L.	Felsite-porphyry.	
SUBRANG 2. DOPOTASSIC. MIHALOSE.						
FeS_2 0.18	Q 42.2 hy 3.4 or 29.5 mt 0.9 ab 8.4 an 8.1 C 5.0	"Bodegang," Kestenthal, Harz Mts.	Kinkeldey.	K. A. Lossen, Z. D. G. G. XXVI, p. 889, 1874. R. T. 1879, p. XIV.	Felsite-porphyry.	Border of dike; cf. No. 16, toscanose.

CLASS I. PERSALANE—Continued.

RANG 3. ALKALICALCIC. RIESENASE—Continued.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	74.52	14.20	1.26	n. d.	0.72	3.47	4.07	0.58	1.18					100.00	
A4. IV.	1.242	.139	.008	(.016)	.018	.063	.066	.006							

CLASS I. PERSALANE.

RANG 1. PERALKALIC. LIPARASE.

1	74.50	12.69	0.67	n. d.	0.30	0.14	0.92	9.92	0.73					99.85	
A3. III	1.242	.124	.004	(.008)	.008	.003	.015	.106							

RANG 1. PERALKALIC. LIPARASE.

1	76.80	11.64	0.66	0.50	trace	0.43	2.53	6.69	0.77					100.02	2.50
A3. III	1.280	.114	.004	.007	—	.008	.040	.071							
2	75.07	11.40	.053	1.28	0.11	0.61	1.15	8.33	1.74	trace			trace	100.22	2.40
A3. III	1.251	.112	.003	.018	.003	.011	.019	.088							
3	74.62	11.96	1.20	0.10	trace	0.36	2.26	7.76	1.02					99.18	2.23
B3. IV	1.244	.117	.008	.001	—	.006	.036	.083							
4	75.04	13.12	2.12	n. d.	0.34	0.40	2.44	6.32	0.76					100.54	
A4. IV	1.251	.127	.013	(.026)	.009	.007	.039	.067							
5	68.99	13.78	0.75	n. d.	0.15	2.01	2.99	8.01	2.89					99.57	
A3. III	1.150	.135	.005	(.010)	.004	.036	.048	.085							

RANG 1. PERALKALIC. LIPARASE.

1	72.26	13.59	1.16	2.18	0.06	1.13	3.85	5.58	0.47		0.45		trace	100.73	2.65
A2. II	1.204	.133	.007	.031	.002	.020	.062	.060			.006				
2	73.09	12.76	1.07	4.28	0.09	0.30	3.16	5.10	0.73		0.40		0.08	101.06	2.66
B2. III	1.218	.125	.007	.060	.002	.005	.051	.054			.005		.001		
3	71.07	12.34	2.25	4.92	0.19	0.55	2.84	5.53	0.72		0.27		trace	100.68	2.68
A2. II	1.185	.121	.014	.068	.005	.010	.046	.059			.003				
4	75.44	13.98	0.54	n. d.	trace	0.50	3.48	5.36	0.77					100.07	2.48
A4. IV	1.257	.137	.003	(.006)	—	.009	.056	.057							
5	74.48	16.20	0.20	n. d.	0.27	0.13	3.78	4.56	0.60					100.22	
A3. III	1.241	.159	.001	(.002)	.007	.002	.061	.049							
6	73.60	13.80	2.00	n. d.	0.50	0.79	4.29	5.22	n. d.					100.20	
A4. IV	1.227	.135	.013	(.026)	.013	.014	.069	.055							

CLASS I. PERSALANE—Continued.

RANG 1. PERALKALIC. LIPARASE—Continued.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp. gr.
1	70.97	13.84	3.21	0.78	0.20	1.26	6.27	1.57	0.74	0.79	0.25			100.09	2.709
A2. II	1.183	.136	.020	.011	.005	.022	.102	.017			.003				

RANG 2. DOMALKALIC. TOSCANASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp. gr.
1	68.94	14.31	2.29	2.75	0.47	2.25	1.13	7.38	0.46					99.98	
A3. III	1.149	.140	.014	.039	.012	.040	.018	.079							
2	69.19	14.12	1.64	1.71	1.66	1.58	1.81	8.45	n. d.			0.15	trace	100.31	2.69
A3. III	1.153	.138	.010	.024	.042	.029	.029	.090				.001			

RANG 2. DOMALKALIC. TOSCANASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp. gr.
1	70.29	14.85	1.20	1.20	0.26	1.09	3.66	5.66	1.36				0.16	99.73	2.12
A2. III	1.172	.146	.008	.017	.007	.020	.059	.061					.002		
2	70.17	14.53	2.54	1.74	0.93	2.29	3.25	3.35	1.53				trace	100.33	
A2. III	1.170	.142	.016	.024	.023	.041	.052	.036							
3	73.96	12.44	3.07	0.55	0.14	1.28	3.00	5.10	1.00					100.54	
[illegible] III	1.2[illegible]	.122	.019	.008	.004	.023	.048	.054							
4	72.24	14.92	1.63	0.23	0.36	1.68	3.51	5.10	n. d.				0.32	99.99	
A3. III	1.204	.146	.010	.003	.009	.030	.056	.054					.005		
5	71.76	[illegible]	1.08	n. d.	0.28	1.48	2.97	5.13	0.60					99.98	
[illegible]	[illegible]	[illegible]	.007	(.014)	.007	.027	.048	.054							
6	[illegible]	[illegible]	2.80	0.08	0.71	1.12	4.13	4.66	n. d.					99.86	
[illegible]	[illegible]	[illegible]	.018	.001	.018	.020	.066	.050							
7	[illegible]	16.40	2.09	1.00	0.85	1.03	4.20	5.22	n. d.					99.99	
[illegible]	[illegible]	.161	.013	.014	.021	.018	.068	.055							
[illegible]	[illegible]	16.40	2.60	0.65	0.85	1.75	3.78	5.31	n. d.					100.14	
[illegible]	[illegible]	.161	.016	.009	.021	.031	.061	.056							
[illegible]	[illegible]	15.96	3.69	1.00	0.78	2.92	3.75	4.14	n. d.					100.44	
[illegible]	[illegible]	[illegible]	.023	.014	.020	.052	.060	.044							
[illegible]	[illegible]	14.44	0.43	1.49	trace	1.08	4.21	4.43	0.40			trace	trace	100.18	2.6[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	.021	—	.020	.068	.047							
	[illegible]	[illegible]	3.15	0.41	1.20	2.92	3.25	3.90	n. d.					100.07	

ORDER 4. QUARDOFELIC. BRITANNARE—Continued.

SUBRANG 4. DOSODIC. KALLERUDOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
S trace Org 0.01	Q 25.4 di 1.1 or 9.5 mt 1.9 ab 53.5 il 0.5 an 4.7 hm 1.9	Muhlenthal, n. Elbingerode, Harz Mountains.	Jacobs.	K. A. Lossen, Sb. Ges. Nat. Fr., 1883, p. 178. R. T. 1884, p. xx.	Quartz-keratophyre.	Near lassenose.

SUBRANG 2. DOPOTASSIC. DELLENOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 27.0 hy 4.5 or 43.9 mt 3.3 ab 9.4 an 11.1 C 0.3	Pochjakörkia, Island Hochland, Finland.	Lemberg.	Lemberg, Arch. Nk. Livl., IV, p. 181, 1867. R. T. 1869, p. l.	Felsite-porphyry.	
Cl_2 trace ZnO trace BaO trace	Q 20.1 di 2.3 or 50.0 hy 5.0 ab 15.2 mt 2.3 an 5.3	Tryberg Waterfall, Schwartzwald, Baden.	Hebenstreit.	Hebenstreit, Btr. Kenntn. Schww., 1877, p. 27. R. T. 1879, p. xii.	Granite.	

SUBRANG 3. SODIPOTASSIC. TOSCANOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 23.6 hy 2.2 or 33.9 mt 1.9 ab 30.9 an 5.6 C 0.6	Harlequin Canyon, Montezuma Range, Nevada.	R. W. Woodward.	C. King, G. Expl. 40th Par. I, p. 652, 1878. R. T. 1879, p. liv.	Liparite.	Sp. gr. low.
Li_2O trace	Q 31.7 hy 3.4 or 20.0 mt 3.7 ab 27.3 an 11.4 C 1.4	Shoshone Peak, Nevada.	R. W. Woodward.	C. King, G. Expl. 40th Par. I, p. 576, 1878. R. T. 1879, p. lxiv.	Dacite.	
	Q 34.4 di 0.8 or 30.0 mt 1.9 ab 25.2 hm 1.8 an 5.6	Camaros Hill, County Wexford, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac., XXIII, p. 608, 1859. R. T. 1869, p. xlvi.	Granite.	
	Q 28.5 hy 0.9 or 30.0 mt 0.7 ab 29.3 hm 1.1 an 8.3 C 0.6	Doochary Bridge, County Donegal, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac., XXIV, 1866. R. T 1869, p. xlvi.	Granite.	
	Q 30.5 hy 2.6 or 30.0 ab 25.2 an 7.5 C 3.5	Poulmounty, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac., XXIII, p. 599, 1859. R. T. 1869, p. xliv.	Granite.	
	Q 24.8 hy 1.8 or 27.8 mt 0.2 ab 34.6 hm 2.7 an 5.6 C 2.5	Ard Malin, County Donegal, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac., XXIV, p. 8, 1866. R. T. 1869, p. xlvi.	Granite.	
	Q 21.4 hy 2.2 or 30.6 mt 3.0 ab 35.6 an 5.0 C 2.0	Tory Island, County Donegal, Ireland.	S. Haughton.	S. Houghton, Tr. R. Ir. Ac., XXIV, 1866. R. T. 1869, p. xlvi.	Granite.	
	Q 21.7 hy 2.1 or 31.1 mt 2.1 ab 32.0 hm 1.1 an 8.6 C 1.3	Arranmore Island, County Donegal, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac., XXIV, 1866. R. T. 1869, p. xlvi.	Granite.	
	Q 23.3 hy 2.0 or 24.5 mt 3.3 ab 31.4 hm 1.4 an 14.5	Poison Glen, County Donegal, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac. XXIV, 1866. R. T. 1869, p. xlvi.	Granite.	
Li_2O trace	Q 28.8 hy 2.4 or 26.1 mt 0.7 ab 35.6 an 5.6 C 0.6	Peterhead, Scotland.	A. H. Phillips.	A. H. Phillips, Q. J. G. S., XXXVI, p. 13, 1880. R. T. 1884, p. xiv.	Granite.	
	Q 26.2 hy 3.0 or 22.8 mt 1.4 ab 27.8 hm 2.2 an 14.5 C 2.4	Creetown, Kirkcudbright, Scotland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac., XXIII, p. 607, 1859. R. T. 1869, p. xliv.	Granite.	

ORDER 4. QUARDOFELIC. BRITANNARE—Continued.

SUBRANG 3. SODIPOTASSIC. TOSCANOSE—Continued.

Inclusive.	Norm.		Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 28.2 or 26.7 ab 36.2 an 5.6	hy 0.4 mt 1.2 hm 1.6	500 feet below summit, Mont Blanc, France.	S. Haughton.	S. Haughton, J. G. Soc. Dubl. IX, p. 219, 1862, R. T. 1869, p. XLIV.	Protogine.	
	Q 32.5 or 22.8 ab 33.5 an 4.5 C 2.6	hy 3.4 mt 0.2	Björketorp, Sect. Linde, Sweden.	Hasselbom	Hummel, Sv. G. Und., Sect. Linde., p. 16, 1873. R. T. 1879, p. XIV.	Granite.	Near liparose.
FeS_2 0.28	Q 26.3 or 22.8 ab 34.6 an 8.1 C 1.4	hy 4.0 mt 0.2 il 0.6	"Bodegang," Kestenthal, Harz Mountains.	Kinkeldy.	K. A. Lossen, Z. D. G. G., XXVI, p. 889, 1874. R. T. 1879, p. XIV.	Granite-porphyry.	Center of dike. cf. No. 1, mihalose.
	Q 31.5 or 26.7 ab 30.9 an 6.1 C 0.9	hy 1.4 mt 1.2	Schaufelgraben, Gleichenberg, Styria.	Frisch.	Ludwig, T. M. P. M., 1877, p. 277. R. T. 1879, p. LII.	Liparite.	
	Q 31.6 or 21.7 ab 28.8 an 10.6 C 2.0	hy 3.4 mt 0.9	Zehnerkopf, West Tyrol.	Stache and von John.	Stache and von John, Jb. Wien. G. R-A., XXVII, p. 237, 1877. R. T. 1879, p. XXII.	Felsite-porphyry.	
	Q 27.2 or 28.9 ab 30.4 an 5.8 C 1.6	hy 5.0 mt 1.4	Zwölfergipfel, West Tyrol.	Stache and von John.	Stache and von John, Jb. Wien. G. R-A., XXVII, p. 237, 1877. R. T. 1879, p. XXII.	Felsite-porphyry.	
	Q 24.2 or 35.6 ab 27.8 an 7.5	hy 3.3	Chiaja di Luna, Ponza, Ponza Islands.	C. Doelter.	C. Doelter, Ds. Wien. Ak., XXXVI, p. 10, 1875. R. T. 1879, p. LII.	Liparite.	
	Q 15.8 or 34.5 ab 32.0 an 8.9	di 1.3 hy 1.6 mt 0.5 hm 3.0	Molivo, Mytilene, Ægean Sea.	K. von Hauer.	K. von Hauer, Vh. Wien. G. R.-A., 1873, p. 220. R. T. 1879, p. LIV.	Perlite.	Iron oxides.

SUBRANG 4. DOSODIC. LASSENOSE.

Inclusive.	Norm.		Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 24.6 or 17.8 ab 34.1 an 15.8 C 0.5	hy 5.5 mt 1.2	Near Lassen Peak, California.	J. W. Shimer.	Hague and Iddings, A. J. S., XXVI, p. 232, 1883. R. T. 1884, p. LXVIII.	Dacite.	In W. T., p. 177, No. 38, lassenose.
ZnO 0.06	Q 20.9 or 11.1 ab 45.6 an 13.9 C 1.3	hy 4.3 mt 2.6	Castillo de la Nueva Guatemala, Guatemela.	Marx.	Marx, Z. D. G. G., XX, p. 521, 1868. R. T., 1869, p. CXVIII.	Andesite.	Dried before analysis. $H_2O+ = 0.27$.
	Q 30.1 or 19.5 ab 41.4 an 4.7	di 2.9 wo 1.3	Dunlewy, County Donegal, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac., XXIV, 1866. R. T. 1869, p. XLVI.	Granite.	Near kallerudose.
	Q 31.6 or 16.7 ab 40.4 an 7.5	di 1.1 hy 2.1 mt 0.9	Harparboda, Sect. Linde, Sweden.	Hasselbom.	Hummel, Sv. G. Und., XLVII, p. 16, 1873. R. T. 1879, p. XIV.	Granite.	
	Q 30.7 or 16.7 ab 38.8 an 6.4	di 4.1 hy 1.8 mt 2.2	Baldersnäs, Ulfserud, Sweden.	Erdmann.	Hummel and Erdmann, Sv. G. Und., XXXV, p. 87, 1870. R. T. 1873, p. X.	Granite.	
	Q 23.2 or 17.8 ab 37.7 an 10.0 C 1.4	hy 3.0 mt 2.3 hm 1.4	Alagez, Armenia.	Plohn.	Abich, G. Armen. Hochl., 1882, p. 35. R. T. 1884, p. LXVIII.	Pitchstone.	

CLASS II. DOSALANE—Continued.

RANG 1. PERALKALIC. PANTELLERASE—Continued.

No.	SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	FeO	MgO	CaO	Na$_2$O	K$_2$O	H$_2$O	CO$_2$	TiO$_2$	P$_2$O$_5$	MnO	Sum	Sp. gr.
1	65.93	11.33	4.65	4.69	1.10	2.36	4.58	3.44	1.83					99.91	
A3. III	1.099	.111	.029	.065	.028	.042	.074	.036							
2	67.89	11.53	4.51	4.52	0.62	1.51	5.79	3.71	0.33					100.41	2.43
A3. III	1.132	.113	.028	.062	.016	.027	.093	.039							
3	67.48	9.70	7.42	2.21	0.77	1.45	7.21	2.94	0.96					100.14	2.68
A3. III	1.125	.095	.046	.030	.019	.026	.116	.031							
4	67.18	14.18	4.00	2.48	0.34	2.78	5.89	4.01	—					100.86	2.40
A3. III	1.120	.139	.025	.035	.009	.050	.095	.043							

RANG 2. DOMALKALIC. DACASE.

No.	SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	FeO	MgO	CaO	Na$_2$O	K$_2$O	H$_2$O	CO$_2$	TiO$_2$	P$_2$O$_5$	MnO	Sum	Sp. gr.
1	61.93	13.18	3.63	2.31	4.59	3.48	2.67	6.11	1.14					99.04	
B3. IV	1.032	.129	.023	.032	.115	.063	.044	.065							
2	64.94	17.50	0.69	3.94	2.83	2.59	3.44	3.11	1.36					100.40	2.72
A3. III	1.082	.171	.004	.055	.071	.046	.055	.033							
3	64.65	14.13	5.24	3.02	1.41	1.65	2.78	5.26	1.97	0.29	0.50		trace	100.90	2.659
A2. II	1.078	.138	.033	.042	.035	.030	.045	.056			.006		—		
4	66.57	15.59	0.37	4.25	1.88	1.85	3.69	5.27	0.62	trace	trace	trace		100.09	2.637
A3. III	1.110	.152	.002	.059	.047	.033	.060	.056			—	—			

RANG 2. DOMALKALIC. DACASE.

No.	SiO$_2$	Al$_2$O$_3$	Fe$_2$O$_3$	FeO	MgO	CaO	Na$_2$O	K$_2$O	H$_2$O	CO$_2$	TiO$_2$	P$_2$O$_5$	MnO	Sum	Sp. gr.
1	65.27	15.76	1.36	3.44	2.14	3.70	4.57	3.97	0.42			0.26		100.89	
A3. III	1.088	.154	.009	.048	.054	.066	.074	.043				.002			
2	56.59	12.41	5.39	10.28	2.02	6.70	4.27	1.02	1.45	trace	0.22	0.44		100.79	
A2. II	.948	.122	.034	.143	.051	.120	.069	.012			.003	.003			
3	63.49	12.42	6.41	1.34	1.32	4.17	4.90	1.78	2.88			trace	0.85	99.56	2.52
A3. III	1.058	.121	.040	.018	.033	.075	.079	.019				—	.012		15°
4	64.39	15.99	1.47	5.98	1.67	2.57	4.96	2.46	0.76			trace	trace	99.25	
B3. IV	1.073	.156	.009	.083	.042	.046	.080	.027							
5	67.74	13.04	4.48	3.81	1.01	3.08	4.80	1.55	0.88					100.39	
A3. III	1.129	.128	.028	.053	.025	.055	.077	.017							
6	70.17	11.10	1.92	2.86	1.23	3.34	3.77	3.23	1.87					99.49	
A3. III	1.170	.109	.012	.040	.031	.060	.061	.034							
7	60.78	16.90	4.79	4.11	2.89	1.50	4.01	2.69	2.84					100.51	2.698
A3. III	1.013	.166	.030	.057	.072	.027	.065	.029							

ORDER 4. QUARDOFELIC. AUSTRARE—Continued.

SUBRANG 3. SODIPOTASSIC. HARZOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 11.5 di 2.8 or 17.8 hy 14.6 ab 23.1 mt 4.4 an 20.3 hm 4.5	West Aston, County Wicklow, Ireland.	S. Haughton	S. Haughton, Tr. R. Ir. Ac., XXIII, p. 619, 1859. R. T. 1869, p. LXIV.	Greenstone (diorite).	Iron oxides? Cf. No. 2, shoshonose.
	Q 10.3 hy 15.3 or 16.1 mt 5.3 ab 20.4 an 30.8 C 0.2	Gäddviken, Animskogssocken, Sweden.	Törnebohm.	Törnebohm, Sv. G. Und., XXXIV, p. 31, 1870. R. T. 1873, p. XVIII.	Diorite.	Near II. 5. 4. 3.
	Q 16.1 di 0.7 or 26.1 hy 9.9 ab 22.0 mt 3.3 an 22.0	Launa Körkia, Island Hochland, Finland.	Lemberg.	Lemberg, Arch. Nk. Livl., IV, p. 179, 1867. R. T. 1869, p. LXIV.	Labradorite-porphyry (diorite).	
	Q 10.5 di 13.5 or 15.0 hy 8.3 ab 20.4 mt 4.6 an 26.7	Hintere Gratspitze, Mte. Cevedale, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 395, 1879. R. T. 1884, p. XXXIV.	Suldenite.	

SUBRANG 4. DOSODIC. TONALOSE.

	Q 18.3 di 4.5 or 13.9 hy 6.6 ab 32.0 mt 4.4 an 22.2 hm 2.7	Hac. de Chuquipoyo, Chimborazo, Ecuador.	A. Schwager.	Gümbel, Sb. Münch. Ak., 1881, p. 348. R. T. 1884, p. LXX.	Andesite.	In W. T., p. 239. No. 77, tonalose.
	Q 13.1 di 0.4 or 7.8 hy 15.4 ab 33.0 mt 3.5 an 24.7	Vildarthal, Tyrol.	von John?	Teller and von John, Jb. Wien. G. R-A., XXXII, p. 653, 1882. R. T. 1884, p. XXVIII.	Quartz-norite.	
	Q 11.5 di 6.0 or 12.2 hy 13.8 ab 27.8 mt 2.1 an 26.4	Lienz, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 400, 1879. R. T. 1884, p. XXXII.	Porphyrite.	
	Q 12.5 di 1.8 or 11.1 hy 15.4 ab 23.6 mt 8.6 an 27.5	Tinnebach, Tyrol.	von John?	Teller and von John, Jb. Wien. G. R-A., XXXII, p. 653, 1882. R. T. 1884, p. XXVIII.	Norite-porphyry.	
	Q 10.2 di 7.7 or 8.3 hy 6.4 ab 33.0 mt 4.9 an 27.8	Hajto, n. Nagyag, Siebenbürgen.	C. Doelter.	C. Doelter, T. M. P. M., 1873, p. 95. R. T. 1879, p. LXIV.	Dacite.	Near andose.

SUBRANG 4.5. PRESODIC. BANDOSE.

SO_3 trace Cl trace	Q 11.3 di 16.9 or 8.3 wo 0.8 ab 20.4 mt 11.5 an 34.2	Portañuela, Yate Volcano, Patagonia.	H. Ziegenspeck.	H. Ziegenspeck, In. Diss., Jena., 1883, p. 29. R. T. 1884, p. LXXIV.	Basalt.	In W. T., p. 249, No. 14, bandose.
	Q 15.8 di 15.6 or 3.3 hy 3.6 ab 23.1 mt 11.1 an 27.8	Stransko, n. Liebstadt, Bohemia.	Werther.	Werther, Jb. Pr. Chem., XCI, p. 330, 1864. R. T. 1869, p. LXXVIII.	Melaphyre.	Cf. No. 9, andose.
	Q 22.0 di 7.3 or 4.5 hy 5.7 ab 25.7 mt 6.0 an 27.0	St. Egidi, Styria.	Niedzwiedki.	Niedzwiedki, T. M. P. M., 1872, p. 255. R. T. 1873, p. XLVIII.	Pitchstone.	
	Q 13.3 di 19.3 or 5.6 hy 3.1 ab 19.9 mt 3.3 an 35.6	Suldenferner, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 341, 1879. R. T. 1884, p. XXX.	Diorite-porphyry.	

CLASS I. PERSALANE—Continued.

RANG 2. DOMALKALIC. TOSCANASE—Continued.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	71.08	17.19	0.52	n. d.	0.43	3.16	5.55	0.92	1.15					100.00	
A4. IV	1.185	.169	.003	(.006)	.011	.044	.099	.010							

RANG 3. ALKALICALCIC. COLORADASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	65.26	14.96	1.14	4.92	0.70	3.30	2.54	4.70	2.16					99.68	2.77
A3. III	1.088	.147	.007	.068	.018	.059	.041	.050							
2	68.79	14.80	2.32	0.85	1.15	3.81	2.46	4.54	0.71		0.31		0.01	99.93	2.68
A2. II	1.147	.145	.014	.012	.029	.068	.040	.048			.004		—		

RANG 3. ALKALICALCIC. COLORADASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	63.19	18.65	4.01	1.89	1.20	4.86	3.69	1.95	0.07		0.18	0.25	0.13	100.07	
A2. II	1.053	.183	.025	.027	.030	.088	.059	.021			.002	.002	.002		
2	67.17	16.96	3.45	1.20	1.50	4.46	3.70	1.55	0.89				trace	100.88	
A3. III	1.120	.166	.022	.017	.038	.080	.060	.017					—		
3	65.71	17.08	2.84	1.79	2.57	5.24	3.87	1.02	n. d.					100.12	
A3. III	1.095	.167	.018	.025	.064	.094	.063	.012							

CLASS I. PERSALANE.

RANG 1. PERALKALIC. NORDMARKASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	66.06	16.46	2.25	1.10	0.19	0.79	6.81	5.52	0.62				0.55	100.35	
A3. III	1.101	.161	.014	.015	.005	.014	.110	.059					.008		

RANG 2. DOMALKALIC. PULASKASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	60.60	17.22	4.37	1.96	0.75	2.87	3.39	6.75	0.80	1.57			0.24	100.52	
A3. III	1.010	.169	.028	.028	.019	.052	.055	.072					.003		
2	62.17	20.83	2.26	2.12	0.45	1.68	4.40	6.76	0.25			0.03	trace	100.95	2.45
B3. IV	1.036	.204	.114	.029	.011	.030	.071	.072				—	—		
3	61.87	18.33	3.23	2.51	0.65	2.11	5.07	6.51	0.46			trace	0.01	101.07 .07	2.45
B3. IV	1.031	.180	.020	.035	.016	.038	.082	.069				—	—	101.00	
4	61.55	17.81	3.01	2.60	0.47	1.69	4.08	7.51	0.86			0.01	trace	99.59	2.46
A3. III	1.026	.174	.019	.036	.012	.030	.066	.080				—	—		
5	61.49	20.02	3.11	2.72	0.52	1.88	3.39	7.13	0.46			0.02	0.01	100.75	2.43
A3. III	1.025	.196	.019	.038	.013	.034	.055	.076				—	—		

ORDER 4. QUARDOFELIC. BRITANNARE—Continued.

SUBRANG 5. PERSODIC. MARIPOSOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 25.6 hy 1.9 or 5.6 ab 51.9 an 12.2 C 1.6	Pascolax, Island Hochland, Finland.	Lemberg.	Lemberg, Arch. Nk. Livl., IV, p. 383, 1867. R T. 1869, p. XLII.	Granite.	

SUBRANG 3. SODIPOTASSIC. AMIATOSE.

	Q 21.0 di 0.8 or 27.5 hy 9.5 ab 21.5 mt 1.6 an 15.6	Flogda Quarry, Bondkyrkasocken, Sweden.	M. Stolpe.	M. Stolpe, Sv. G. Und., XXXI, p. 20, 1869. R. T. 1873, p. X.	Granite.	Near toscanose. Nearly in dosalane.
	Q 28.0 di 1.9 or 26.7 hy 2.0 ab 21.0 mt 1.9 an 15.9 il 0.6 hm 1.0	Barr-Andlau, Vogesen.	Unger.	H. Rosenbusch, Steig. Schiefer, 1877, p. 147. R. T. 1879, p. XIV.	Granitite.	

SUBRANG 4. DOSODIC. YELLOWSTONOSE.

	Q 22.0 hy 3.0 or 11.7 mt 5.8 ab 30.9 il 0.3 an 24.5 C 1.5	Mount Tajumbina, Peru.	C. Hoepfner.	C. Hoepfner, N. J., 1881, II, p. 189. R. T. 1884, p. LXVI.	Dacite.	In W. T., p. 191. No. 47, yellowstonose.
	Q 27.6 hy 3.8 or 9.5 mt 3.9 ab 31.4 hm 0.8 an 22.2 C 0.9	Nagy-Sebes, Siebenbürgen, Hungary.	C. Doelter.	C. Doelter, T. M. P. M., 1873, p. 93. R. T. 1879, p. LXIV.	Dacite.	
	Q 23.3 di 0.4 or 6.7 hy 7.1 ab 33.0 mt 4.2 an 25.6	Dognacska, Banat, Hungary.	Niedzwiedzki.	Niedzwiedzki, T. M. P. M., 1873, p. 256. R. T. 1879, p. XXXII.	Quartz-diorite.	Near tonalose.

ORDER 5. PERFELIC. CANADARE.

SUBRANG 4. DOSODIC. NORDMARKOSE.

	Q 4.5 ac 3.7 or 32.8 di 3.3 ab 53.5 mt 1.4	Hohenburg, n. Berkum, Rhenish Prussia.	Laspeyres.	Laspeyres, Vh. Nh. Ver. Bonn, X, p. 394, 1883. R. T. 1884, p. XLVIII.	Liparite.	Near phlegrose.

SUBRANG 3. SODIPOTASSIC. PULASKOSE.

	Q 8.1 di 2.2 or 40.0 hy 0.9 ab 28.8 mt 6.3 an 11.7	Arzbacherkopf, Westerwald.	Gümbel.	Gümbel, Sb. Münch. Ak., 1882, p. 220. R. T. 1884, p. L.	Trachyte.	
Cl trace	Q 5.5 hy 3.1 or 40.0 mt 3.3 ab 37.2 an 8.3 C 3.2	Monte Tabor, Ischia.	C. W. C. Fuchs.	C. W. C. Fuchs, T. M. P. M., 1872, p. 229. R. T. 1873, p. XXXVI.	Trachyte.	
Cl 0.32	Q 6.7 di 0.9 or 38.4 hy 3.1 ab 32.5 mt 4.6 an 9.5 so 4.9	Monte Vetta, Ischia.	C. W. C. Fuchs.	C. W. C. Fuchs, T. M. P. M., 1872, p. 232. R. T. 1873, p. XXXVIII.	Trachyte.	
	Q 3.8 di 0.5 or 44.5 hy 3.2 ab 34.6 mt 4.4 an 7.8	Punta della Cima, Ischia.	C. W. C. Fuchs.	C. W. C. Fuchs, T. M. P. M.. 1872, p. 230. R. T. 1873, p. XXXVI.	Trachyte.	
	Q 8.3 hy 3.8 or 42.3 mt 4.4 ab 28.8 an 9.5 C 3.2	Marecocco, Ischia.	C. W. C. Fuchs.	C. W. C. Fuchs, T. M. P. M., 1872, p. 229. R. T. 1873, p. XXXVI.	Trachyte.	

ORDER 5. PERFELIC. CANADARE—Continued.

SUBRANG 3. SODIPOTASSIC. PULASKOSE—Continued.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 3.8 hy 1.8 or 37.3 mt 6.0 ab 41.4 an 8.1 C 1.9	Monte Rotaro, Ischia.	C. W. C. Fuchs.	C. W. C. Fuchs, T. M. P. M., 1872, p. 232. R. T. 1873, p. xxxviii.	Trachyte-obsidian.	
	Q 0.4 hy 4.9 or 45.6 mt 3.9 ab 32.0 an 10.8 C 2.9	Panza, Ischia.	C. W. C. Fuchs.	C. W. C. Fuchs, T. M. P. M., 1872, p. 230. R. T. 1873, p. xxxvi.	Trachyte.	

SUBRANG 4. DOSODIC. LAURVIKOSE.

	Q 0.3 di 2.0 or 31.1 hy 1.8 ab 50.3 mt 6.0 an 7.8	Monte dell'Imperatore, Ischia.	C. W. C. Fuchs.	C. W. C. Fuchs, T. M. P. M., 1872, p. 231. R. T. 1873, p. xxxviii.	Trachyte.	Near pulaskose.
	Q 7.9 di 4.7 or 16.7 mt 7.4 ab 49.3 an 14.7	Montagna Grande, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 155, 1884. R. T. 1884, p. lxviii.	Augite-andesite.	In W. T., p. 203, No. 24, laurvikose.
	Q 5.0 di 3.3 or 23.4 mt 7.4 ab 52.4 an 8.1	Porto Scauri, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 164, 1884. R. T. 1884, p. lxviii.	Augite-andesite.	In W. T., p. 203, No. 25, laurvikose.
	or 25.6 di 2.4 ab 50.3 ol 4.1 an 7.2 mt 3.2 ne 8.5	Montagna Grande, Pantelleria.	E. Maegis.	H. Förstner, Z. K., VIII, p. 155, 1884. R. T. 1884, p. lxviii.	Augite-andesite.	In W. T., p. 203, No. 26, laurvikose.

ORDER 6. LENDOFELIC. RUSSARE.

SUBRANG 4. DOSODIC. MIASKOSE.

ZrO_2 trace SO_3 0.22 Cl 0.07 F trace Li_2O trace	or 25.0 di 1.7 ab 45.1 mt 4.2 an 5.0 ne 15.1	Magdeberg, Hegau, Germany.	G. F. Föhr.	G. F. Föhr, In. Diss., Wurzburg, 1883, p. 32. R. T. 1884, p. liv.	Phonolite.	In W. T., p. 211, No. 40, miaskose.
SO_3 0.23 Cl 0.06 F trace Li_2O trace Cu 0.18	or 28.9 di 3.4 ab 35.6 wo 2.3 an 3.6 mt 3.2 ne 19.0	Staufen, Hegau.	G. F. Föhr.	G. F. Föhr, In. Diss., Wurzburg, 1883, p. 28. R. T. 1884, p. lii.	Phonolite.	In W. T., p. 211, No. 41, miaskose.
SO_3 0.41 Cl 0.08 F trace NiO trace Cu 0.12 Zn trace	or 20.6 di 3.4 ab 40.9 wo 0.8 an 6.1 mt 2.8 ne 18.5 il 0.5 no 2.6	Hohentwiel, Hegau.	G. F. Föhr.	G. F. Föhr, In. Diss., Wurzburg, 1883, p. 28. R. T. 1884, p. lii.	Phonolite.	In W. T., p. 213, No. 42, miaskose.
SO_3 0.46 Cl 0.07 Li_2O trace	or 20.6 di 4.4 ab 38.8 wo 1.9 an 1.1 mt 3.0 ne 27.8	Hohentwiel, Hegau.	Bernath.	Bernath, Btr. Kenntn. Phon. Hohentw., Berne, 1877, p. 41. R. T. 1879, p. lviii.	Phonolite.	Cf. Nos. 40–42, miaskose, W. T., p. 213.
	or 40.0 ol 2.9 ab 21.5 an 3.6 ne 31.0	Ditro, Siebenbürgen, Hungary.	Fellner.	Fellner, Vh. Wien., G. R.-A., 1867, p. 286. R. T. 1869, p. lx.	Ditroite.	Cf. No. 46, miaskose, W. T., p. 213.

SUBRANG 4. DOSODIC. VIEZZENOSE.

SO_3 0.57 Cl trace S trace	or 26.1 di 6.6 ab 33.5 ol 2.9 an 10.0 mt 0.9 ne 16.8 il 0.8	Campanario, Palma, Canary Islands.	Mardner.	Sauer, Unters. Phon. Gest. Canar., 1876, p. 60. R. T. 1879, p. lxvi.	Hornblende-andesite.	Calc. from sol. and insol.
SO_3 2.97 Cl 0.18	or 35.0 di 6.4 ab 7.9 ol 2.6 an 15.3 mt 3.3 ne 0.3 so 1.9 no 26.3	Sant' Antao, Cape Verde.	Kertscher.	C. Doelter, Die Capverden., 1882, p. 21. R. T. 1884, p. lxii.	Leucitophyre.	Near essexose.

CLASS I. PERSALANE.

RANG I. PERALKALIC. VARINGASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	68.54	9.49	8.60	3.23	0.42	0.54	3.14	5.11	0.30		1.36	trace		100.73	2.789
A2. II.	1.142	.093	.054	.044	.011	.010	.051	.054			.017	—			16°
2	70.30	6.32	9.23	1.40	0.89	0.84	7.70	2.50	0.82					100.00	2.69
A3. III.	1.172	.062	.057	.019	.022	.015	.124	.026							

RANG 2. DOMALKALIC.

1	72.32	13.37	0.57	2.34	3.57	1.88	2.76	2.30	0.68					99.79	
A3. III.	1.205	.131	.004	.032	.089	.034	.045	.024							

RANG 4. DOCALCIC.

1	66.88	11.69	1.68	8.94	3.55	5.45	1.25	0.20	1.03	trace		trace		100.67	
A3. III.	1.115	.115	.011	.124	.089	.097	.020	.002		—		—			

CLASS II. DOSALANE.

RANG 1. PERALKALIC. PANTELLERASE.

1	71.50	10.79	3.52	2.88	0.31	0.15	2.76	6.87	1.00	0.13	0.25		0.30	100.46	
A2. II.	1.192	.106	.022	.040	.008	.003	.045	.073			.003		.004		

RANG 1. PERALKALIC. PANTELLERASE.

1	65.80	12.80	6.64	0.18	1.78	2.92	4.16	4.40	1.20					99.88	
A3. III.	1.097	.125	.041	.003	.045	.052	.067	.047							
2	68.75	11.40	4.30	3.30	1.46	1.24	5.37	4.22	0.30		in SiO_2		trace	100.34	
A3. III.	1.146	.112	.027	.046	.037	.022	.087	.045					—		
3	69.61	8.02	7.17	2.83	0.65	0.88	7.47	2.88	0.74					100.25	2.44
A3. III.	1.160	.078	.045	.039	.016	.016	.120	.031							
4	69.02	10.09	4.42	4.56	0.76	1.45	6.29	3.70	n. d.					100.58	2.46
A3. III.	1.150	.099	.027	.063	.019	.026	.101	.039							
5	68.33	10.94	3.74	5.41	0.16	1.36	7.09	4.08	n. d.					101.36	2.48
B3. IV.	1.139	.107	.023	.075	.004	.024	.115	.044							

ORDER 3. QUARFELIC. HISPANARE.

SUBRANG 3. SODIPOTASSIC. VARINGOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
Cl trace CuO trace	Q 31.0 ac 5.5 or 30.0 di 2.2 ab 20.4 mt 6.3 il 2.6 hm 2.4	Altendiez, Nassau.	Senftner.	J. Petersen, N. J., 1872, p. 593. R. T. 1873, p. xii.	Felsite-porphyry.	
	Q 29.1 ac 26.2 or 14.5 ns 3.9 ab 18.9 di 3.5 hy 3.1	Khartibugal, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 173, 1884. R. T. 1884, p. lxvi.	Pantellerite.	In W. T., p. 219, No. 4, varingose.

SUBRANG 4. DOSODIC.

	Q 36.4 hy 12.6 or 13.3 mt 0.9 ab 23.6 an 9.5 C 2.9	Fabbiasco, n. Lugano, Piedmont.	Slaytor.	T. Harada, N. J. B. B., II, p. 42, 1883. R. T. 1884, p. xviii.	Felsophyre.	Alkalies low?

SUBRANG 4,5. PRESODIC.

	Q 35.5 di 0.9 or 1.1 hy 23.4 ab 10.5 mt 2.6 an 25.9	Little Falls, Minnesota.	Streng.	Streng, N. J., 1877, p. 230. R. T. 1879, p. xxxvi.	Quartz-diorite.	

ORDER 4. QUARDOFELIC. AUSTRARE.

SUBRANG 2. DOPOTASSIC.

	Q 28.2 ac 5.5 or 40.6 di 0.7 ab 17.8 hy 4.0 mt 2.3 il 0.5	Monte Mufetto, Serimando Valley, Bergamask Alps.	Gümbel.	Gümbel, Sb. Münch. Ak., 1880, p. 189. R. T. 1884, p. xviii.	Felsite-porphyry.	Near omeose.

SUBRANG 3. SODIPOTASSIC. GRORUDOSE.

	Q 18.5 di 8.9 or 26.1 hy 0.4 ab 35.1 mt 0.7 an 3.1 hm 6.1	Urrismenagh, County Donegal, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac., XXIV, 1866. R. T. 1869, p. xlvi.	Granite.	Iron oxides?
	Q 17.8 ac 9.2 or 25.0 di 5.1 ab 35.1 hy 6.3 mt 1.6	Balduinstein, Hesse-Nassau.	Gümbel.	Gümbel, Sb. Münch. Ak., 1882, p. 210. R. T. 1884, p. xvi.	Felsite-porphyry.	
	Q 24.8 ac 20.8 or 17.2 ns 3.5 ab 24.6 di 3.8 hy 4.8	Khartibugal, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 173, 1884. R. T. 1884, p. lxvi.	Pantellerite.	In W. T., p. 224, No. 7, grorudose.
CuO 0.29	Q 19.6 ac 12.1 or 21.7 ns 1.7 ab 31.4 di 6.3 hy 7.0	Cuddia Mida, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 182, 1884. R. T. 1884, p. lxvi.	Pantellerite.	In W. T., p. 221, No. 8, grorudose.
CuO 0.25	Q 14.5 ac 10.6 or 24.5 ns 4.9 ab 33.0 di 6.0 hy 7.1	Khania, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 170, 1884. R. T. 1884, p. lxvi.	Pantellerite.	Not in W. T.

CLASS II. DOSALANE—Continued.

RANG 1. PERALKALIC. PANTELLERASE—Continued.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp. gr.
1	65.93	11.33	4.65	4.69	1.10	2.36	4.58	3.44	1.83					99.91	
A3. III	1.099	.111	.029	.065	.028	.042	.074	.036							
2	67.89	11.53	4.51	4.52	0.62	1.51	5.79	3.71	0.33					100.41	2.43
A3. III	1.132	.113	.028	.062	.016	.027	.093	.039							
3	67.48	9.70	7.42	2.21	0.77	1.45	7.21	2.94	0.96					100.14	2.68
A3. III	1.125	.095	.046	.030	.019	.026	.116	.031							
4	67.18	14.18	4.00	2.48	0.34	2.78	5.89	4.01	—					100.86	2.40
A3. III	1.120	.139	.025	.035	.009	.050	.095	.043							

RANG 2. DOMALKALIC. DACASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp. gr.
1	61.93	13.18	3.63	2.31	4.59	3.48	2.67	6.11	1.14					99.04	
B3. IV	1.032	.129	.023	.032	.115	.063	.044	.065							
2	64.94	17.50	0.69	3.94	2.83	2.59	3.44	3.11	1.36					100.40	2.72
A3. III	1.082	.171	.004	.055	.071	.046	.055	.033							
3	64.65	14.13	5.24	3.02	1.41	1.65	2.78	5.26	1.97	0.29	0.50		trace	100.90	2.659
A2. II	1.078	.138	.033	.042	.035	.030	.045	.056			.006		—		
4	66.57	15.59	0.37	4.25	1.88	1.85	3.69	5.27	0.62	trace	trace	trace		100.09	2.637
A3. III	1.110	.152	.002	.059	.047	.033	.060	.056			—	—			

RANG 2. DOMALKALIC. DACASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp. gr.
1	65.27	15.76	1.36	3.44	2.14	3.70	4.57	3.97	0.42			0.26		100.89	
A3. III	1.088	.154	.009	.048	.054	.066	.074	.043				.002			
2	56.59	12.41	5.39	10.28	2.02	6.70	4.27	1.02	1.45	trace	0.22	0.44		100.79	
A2. II	.943	.122	.034	.143	.051	.120	.069	.012			.003	.003			
3	63.49	12.42	6.41	1.34	1.32	4.17	4.90	1.78	2.88			trace	0.85	99.56	2.52
A3. III	1.058	.121	.040	.018	.033	.075	.079	.019				—	.012		15°
4	64.39	15.99	1.47	5.98	1.67	2.57	4.96	2.46	0.76			trace	trace	99.25	
B3. IV	1.073	.156	.009	.083	.042	.046	.080	.027							
5	67.74	13.04	4.48	3.81	1.01	3.08	4.80	1.55	0.88					100.39	
A3. III	1.129	.128	.028	.053	.025	.055	.077	.017							
6	70.17	11.10	1.92	2.86	1.23	3.34	3.77	3.23	1.87					99.49	
A3. III	1.170	.109	.012	.040	.031	.060	.061	.034							
7	60.78	16.90	4.79	4.11	2.89	1.50	4.01	2.69	2.84					100.51	2.698
A3. III	1.013	.166	.080	.057	.072	.027	.065	.029							

ORDER 4. QUARDOFELIC. AUSTRARE—Continued.

SUBRANG 4. DOSODIC. PANTELLEROSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 19.9 di 9.6 or 20.0 hy 2.7 ab 38.8 mt 6.7 an 0.3	Yxsta, Sect. Örebro, Sweden.	Hasselbom.	Gumälius, Sv. G. Und., XLVIII, p. 18, 1873. R. T. 1879, p. xiv.	Granite.	
	Q 16.9 ac 8.8 or 21.7 di 6.5 ab 38.8 hy 5.3 mt 2.1	Monte San Elmo, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 186, 1884. R. T. 1884, p. lxvi.	Pantellerite.	In W. T., p. 221, No. 3, pantellerose.
	Q 17.4 ac 21.3 or 17.2 ns 0.8 ab 33.5 di 6.2 hy 2.8	Monte San Elmo, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 186, 1884. R. T. 1884, p. lxvi.	Pantellerite.	In W. T., p. 221, No. 4, pantellerose.
	Q 13.3 di 4.4 or 23.9 wo 3.5 ab 49.8 mt 5.8 an 0.3	Cala Porticello, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 133, 1883. R. T. 1884, p. l.	Liparite.	Not in W. T
		SUBRANG 3. SODIPOTASSIC. ADAMELLOSE.				
	Q 10.3 di 9.4 or 36.1 hy 8.3 ab 23.1 mt 5.3 an 5.6	Laveline, Vogesen,	van Werveke.	H. Rosenbusch, N. J., 1881, I, p. 235. R. T. 1884, p. xiv.	Granite.	
	Q 21.0 hy 13.8 or 18.4 mt 0.9 ab 28.8 an 12.8 C 3.8	Lippenhof, n. Tryberg, Schwarzwald, Baden.	Gattermann?	G. H. Williams, N. J. B. B., II, p. 624, 1883. R. T. 1884, p. xxx.	Quartz-diorite-porphyry.	Near dacase, cf. No. 12, adamellose, W. T., p. 223.
	Q 22.4 hy 3.9 or 31.1 mt 7.7 ab 23.6 il 0.9 an 8.3 C 0.7	Corällchen, n. Liebenstein, Thuringia.	G. Pringsheim.	G. Pringsheim, Z. D. G. G., XXXII, p. 144, 1880. R. T. 1884, p. xvi.	Granite-porphyry.	Near toscanose.
CuO trace	Q 14.6 hy 12.2 or 31.1 mt 0.5 ab 31.4 an 9.2 C 0.3	Kirche Wange, Silesia.	O. Jung.	O. Jung, Z. D. G. G., XXXV, p. 830, 1883. R. T. 1884, p. xvi.	Granite-porphyry.	Near toscanose.
		SUBRANG 4. DOSODIC. DACOSE.				
	Q 11.6 di 6.7 or 23.9 hy 6.8 ab 38.8 mt 2.0 an 10.3	Watab, Minnesota.	Streng.	Streng, N. J., 1877, p. 230. R. T. 1879, p. xxxvi.	Quartz-diorite.	Near adamellose.
	Q 8.8 di 16.4 or 6.7 hy 11.1 ab 36.2 mt 7.9 an 11.4 ap 1.0	Sauk Center, Minnesota.	Streng.	Streng, N. J., 1877, p. 227. R. T. 1879, p. xxxiv.	Quartz-diorite.	Near III, 4, 2, 4.
SO	Q 20.3 di 7.2 or 10.6 wo 2.2 ab 41.4 mt 4.2 an 6.4 hm 3.5	Yate Volcano, Patagonia.	H. Ziegenspeck.	H. Ziegenspeck, In. Diss., Jena, 1883, p. 46. R. T. 1884, p. lxxii.	Augite-andesite.	In W. T., p. 227, No. 11, dacose.
	Q 12.2 hy 14.0 or 15.0 mt 2.1 ab 41.9 an 12.8 C 0.3	Peterhead, Scotland.	A. Phillips.	A. Phillips, Q. J. G. S., XXXVI, p. 13, 1880. R. T. 1884, p. xiv.	Segregation in granite.	Cf. No. 10, toscanose.
	Q 25.6 di 4.9 or 9.5 hy 3.4 ab 40.4 mt 6.5 an 9.5	Finaker, Sect. Linde, Sweden.	Hummel.	Hummel, Sv. G. Und., XLVII, p. 16, 1873. R. T. 1879, p. xiv.	Granite.	
	Q 28.0 di 10.6 or 18.9 hy 1.5 ab 32.0 mt 2.8 an 3.9	Klausen, Vildarthal, Tyrol.	von John?	Teller and von John, Jb. Wien. G. R-A., XXXII, p. 653, 1882. R. T. 1884, p. xxviii.	Quartz-diorite.	
	Q 17.8 hy 10.8 or 16.1 mt 7.0 ab 34.1 an 7.5 C 4.6	Suldenferner, Mte. Cevedale, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 403, 1879. R. T. 1884, p. xxxiv.	Quartz-porphyrite.	

CLASS I. PERSALANE—Continued.

RANG 2. DOMALKALIC. TOSCANASE—Continued.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
12	72.96	14.00	2.42	0.38	0.14	1.12	4.33	4.47	n. d.				0.40	100.22	2.671
A3. III	1.216	.187	.015	.005	.004	.020	.069	.048					.006		
13	73.88	14.86	0.10	1.64	0.23	0.89	3.94	3.89	0.82					100.25	
A3. III	1.231	.146	.001	.022	.006	.016	.064	.041							
14	70.40	15.29	0.09	1.69	0.58	1.62	4.09	3.89	1.13		0.28	0.22		99.51	2.68
A2. II	1.173	.150	.001	.024	.015	.029	.066	.041			.004	.001			
15	73.39	14.12	0.77	0.67	0.29	1.25	3.66	4.47	1.22					99.84	
A3. III	1.223	.138	.005	.010	.007	.022	.059	.048							
16	71.65	15.58	0.64	2.21	0.05	2.13	3.44	3.66	1.48				trace	100.84	2.679
A3. III	1.194	.152	.004	.031	.001	.038	.055	.039							
17	71.55	15.00	0.87	3.01	0.06	1.21	3.61	4.92	0.75				trace	100.98	2.661
A3. III	1.193	.147	.006	.042	.002	.021	.058	.052							
18	71.12	14.58	1.69	n. d.	0.15	1.50	3.26	6.01	0.95				trace	99.26	
B4. V	1.185	.143	.011	(.022)	.004	.027	.053	.064					—		
19	65.66	15.78	3.25	0.16	0.88	2.07	3.77	5.82	3.45					100.84	2.459
A3. III	1.094	.155	.021	.002	.022	.038	.061	.062							

RANG 2. DOMALKALIC. TOSCANASE.

1	69.36	16.23	0.88	1.53	1.34	3.17	4.06	3.02	0.45					100.04	
A3. III	1.156	.159	.005	.021	.034	.057	.065	.032							
2	67.91	17.38	1.77	1.25	1.35	2.81	5.43	1.84	—				0.04	99.84	
A3. III	1.132	.170	.011	.018	.034	.050	.087	.020							
3	75.24	13.36	0.60	n. d.	0.14	2.25	4.86	3.27	n. d.					99.72	
A4. IV	1.254	.181	.004	(.008)	.004	.040	.079	.035							
4	75.05	13.66	0.62	1.11	0.46	1.82	4.78	2.84	0.36					100.70	
A3. III	1.251	.134	.004	.015	.012	.032	.077	.030							
5	74.04	13.01	0.80	0.95	1.02	2.33	4.60	2.75	0.86				trace	100.39	
A3. III	1.234	.127	.005	.014	.026	.041	.074	.030							
6	66.69	15.72	3.10	0.68	1.18	1.98	4.45	2.97	2.86					99.63	2.287
A3. III	1.112	.154	.019	.010	.030	.036	.072	.032							

ORDER 4. QUARDOFELIC. BRITANNARE—Continued.

SUBRANG 3. SODIPOTASSIC. TOSCANOSE—Continued.

Inclusive.	Norm.		Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 28.2 or 26.7 ab 36.2 an 5.6	hy 0.4 mt 1.2 hm 1.6	500 feet below summit, Mont Blanc, France.	S. Haughton.	S. Haughton, J. G. Soc. Dubl. IX, p. 219, 1862, R. T. 1869, p. xliv.	Protogine.	
	Q 32.5 or 22.8 ab 33.5 an 4.5 C 2.6	hy 3.4 mt 0.2	Björketorp, Sect. Linde, Sweden.	Hasselbom	Hummel, Sv. G. Und., Sect. Linde., p. 16, 1873. R. T. 1879, p. xiv.	Granite.	Near liparose.
FeS_2 0.28	Q 26.3 or 22.8 ab 34.6 an 8.1 C 1.4	hy 4.0 mt 0.2 il 0.6	"Bodegang," Kestenthal, Harz Mountains.	Kinkeldy.	K. A. Lossen, Z. D. G. G., XXVI, p. 889, 1874. R. T. 1879, p. xiv.	Granite-porphyry.	Center of dike. cf. No. 1, mihalose.
	Q 31.5 or 26.7 ab 30.9 an 6.1 C 0.9	hy 1.4 mt 1.2	Schaufelgraben, Gleichenberg, Styria.	Frisch.	Ludwig, T. M. P. M., 1877, p. 277. R. T. 1879, p. lii.	Liparite.	
	Q 31.6 or 21.7 ab 28.8 an 10.6 C 2.0	hy 3.4 mt 0.9	Zehnerkopf, West Tyrol.	Stache and von John.	Stache and von John, Jb. Wien. G. R-A., XXVII, p. 237, 1877. R. T. 1879, p. xxii.	Felsite-porphyry.	
	Q 27.2 or 28.9 ab 30.4 an 5.8 C 1.6	hy 5.0 mt 1.4	Zwölfergipfel, West Tyrol.	Stache and von John.	Stache and von John, Jb. Wien. G. R-A., XXVII, p. 237, 1877. R. T. 1879, p. xxii.	Felsite-porphyry.	
	Q 24.2 or 35.6 ab 27.8 an 7.5	hy 3.3	Chiaja di Luna, Ponza, Ponza Islands.	C. Doelter.	C. Doelter, Ds. Wien. Ak., XXXVI, p. 10, 1875. R. T. 1879, p. lii.	Liparite.	
	Q 15.8 or 34.5 ab 32.0 an 8.9	di 1.3 hy 1.6 mt 0.5 hm 3.0	Molivo, Mytilene, Ægean Sea.	K. von Hauer.	K. von Hauer, Vh. Wien. G. R.-A., 1873, p. 220. R. T. 1879, p. liv.	Perlite.	Iron oxides.

SUBRANG 4. DOSODIC. LASSENOSE.

Inclusive.	Norm.		Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 24.6 or 17.8 ab 34.1 an 15.8 C 0.5	hy 5.5 mt 1.2	Near Lassen Peak, California.	J. W. Shimer.	Hague and Iddings, A. J. S., XXVI, p. 232, 1883. R. T. 1884, p. lxviii.	Dacite.	In W. T., p. 177, No. 38, lassenose.
ZnO 0.06	Q 20.9 or 11.1 ab 45.6 an 13.9 C 1.3	hy 4.3 mt 2.6	Castillo de la Nueva Guatemala, Guatemela.	Marx.	Marx, Z. D. G. G., XX, p. 521, 1868. R. T., 1869, p. cxviii.	Andesite.	Dried before analysis. $H_2O+ = 0.27$.
	Q 30.1 or 19.5 ab 41.4 an 4.7	di 2.9 wo 1.3	Dunlewy, County Donegal, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac., XXIV, 1866. R. T. 1869, p. xlvi.	Granite.	Near kallerudose.
	Q 31.6 or 16.7 ab 40.4 an 7.5	di 1.1 hy 2.1 mt 0.9	Harparboda, Sect. Linde, Sweden.	Hasselbom.	Hummel, Sv. G. Und., XLVII, p. 16, 1873. R. T. 1879, p. xiv.	Granite.	
	Q 30.7 or 16.7 ab 38.8 an 6.4	di 4.1 hy 1.8 mt 2.2	Baldersnäs, Ulfserud, Sweden.	Erdmann.	Hummel and Erdmann, Sv. G. Und., XXXV, p. 87, 1870. R. T. 1873, p. x.	Granite.	
	Q 23.2 or 17.8 ab 37.7 an 10.0 C 1.4	hy 3.0 mt 2.3 hm 1.4	Alagez, Armenia.	Plohn.	Abich, G. Armen. Hochl., 1882, p. 35. R. T. 1884, p. lxviii.	Pitchstone.	

CLASS I. PERSALANE—Continued.

RANG 2. DOMALKALIC. PULASKASE—Continued.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	Mno	Sum	Sp. gr.
6	60.77	19.83	4.14	2.43	0.34	1.63	4.90	6.27	0.24			trace	trace	100.55	2.44
A3. III	1.013	.194	.026	.033	.009	.029	.079	.067				—	—		
7	59.12	21.46	2.68	2.72	0.84	2.16	3.78	7.66	0.25			trace		100.67	
A3. III	.985	.210	.017	.038	.021	.039	.061	.082				—			

RANG 2. DOMALKALIC. PULASKASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	Mno	Sum	Sp. gr.
1	61.05	18.35	4.21	2.12	0.90	2.05	5.94	5.28	0.32			trace	0.04	100.26	2.53
A3. III	1.018	.180	.026	.029	.023	.037	.096	.056				—	.001		
2	61.47	18.09	5.14	3.06	1.32	3.00	5.85	2.83	n. d.					100.76	2.72
A3. III	1.025	.177	.032	.043	.033	.053	.094	.030							
3	61.43	17.51	5.11	2.30	0.54	2.45	6.22	3.95	n. d.					99.51	2.34
A3. III	1.024	.171	.032	.032	.014	.044	.100	.042							
4	60.24	20.28	2.32	3.88	0.50	1.96	7.80	4.28	n. d.					101.26	
C3. V	1.004	.198	.014	.054	.013	.036	.126	.046							

CLASS I. PERSALANE.

RANG 1. PERALKALIC. MIASKASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	Mno	Sum	Sp. gr.
1	56.43	20.58	2.88	1.28	0.28	1.45	8.62	4.23	2.90		trace	0.06	0.66	99.66	2.499
A2. II	.941	.202	.018	.018	.007	.026	.139	.045			—	—	.009		
2	55.92	20.35	2.16	0.94	0.62	2.21	8.35	4.83	3.51			0.18	0.50	100.04	2.452
A2. II	.932	.200	.014	.013	.016	.039	.135	.052				.001	.007		
3	55.01	21.67	1.95	1.86	0.13	2.12	9.78	3.54	2.17		0.27	0.08	0.22	99.41	2.513
A2. II	.917	.212	.012	.026	.003	.038	.158	.037			.003	.001	.003		
4	55.21	21.78	2.06	2.01	0.13	2.10	10.64	3.48	2.07		trace		trace	100.00	
A2. II	.920	.213	.013	.028	.003	.038	.172	.037			—				
5	56.30	24.14	1.99	n. d.	0.13	0.69	9.28	6.79	1.58					100.90	2.48
A4. IV	.938	.236	.013	(.026)	.003	.013	.150	.072							

RANG 2. DOMALKALIC. VIEZZENASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	Mno	Sum	Sp. gr.
1	55.40	21.03	1.64	3.04	0.91	3.57	7.64	4.42	0.95		0.43	0.23	trace	99.83	2.54–2.59
A2. II	.923	.206	.010	.042	.023	.064	.123	.047			.005	.002	—		
2	48.46	21.81	2.17	3.75	0.68	4.58	8.41	5.86	2.08		trace			100.90	
A3. III	.808	.214	.014	.052	.017	.082	.135	.063			—				

ORDER 5. PERFELIC. CANADARE—Continued.

SUBRANG 3. SODIPOTASSIC. PULASKOSE—Continued.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 3.8 or 37.3 ab 41.4 an 8.1 C 1.9 hy 1.8 mt 6.0	Monte Rotaro, Ischia.	C. W. C. Fuchs.	C. W. C. Fuchs, T. M. P. M., 1872, p. 232. R. T. 1873, p. xxxviii.	Trachyte-obsidian.	
	Q 0.4 or 45.6 ab 32.0 an 10.8 C 2.9 hy 4.9 mt 3.9	Panza, Ischia.	C. W. C. Fuchs.	C. W. C. Fuchs, T. M. P. M., 1872, p. 230. R. T. 1873, p. xxxvi.	Trachyte.	

SUBRANG 4. DOSODIC. LAURVIKOSE.

	Q 0.3 or 31.1 ab 50.3 an 7.8 di 2.0 hy 1.8 mt 6.0	Monte dell'Imperatore, Ischia.	C. W. C. Fuchs.	C. W. C. Fuchs, T. M. P. M., 1872, p. 231. R. T. 1873, p. xxxviii.	Trachyte.	Near pulaskose.
	Q 7.9 or 16.7 ab 49.3 an 14.7 di 4.7 mt 7.4	Montagna Grande, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 155, 1884. R. T. 1884, p. lxviii.	Augite-andesite.	In W. T., p. 203, No. 24, laurvikose.
	Q 5.0 or 23.4 ab 52.4 an 8.1 di 3.3 mt 7.4	Porto Scauri, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 164, 1884. R. T. 1884, p. lxviii.	Augite-andesite.	In W. T., p. 203, No. 25, laurvikose.
	or 25.6 ab 50.3 an 7.2 ne 8.5 di 2.4 ol 4.1 mt 3.2	Montagna Grande, Pantelleria.	E. Maegis.	H. Förstner, Z. K., VIII, p. 155, 1884. R. T. 1884, p. lxviii.	Augite-andesite.	In W. T., p. 203, No. 26, laurvikose.

ORDER 6. LENDOFELIC. RUSSARE.

SUBRANG 4. DOSODIC. MIASKOSE.

ZrO_2 trace SO_3 0.22 Cl 0.07 F trace Li_2O trace	or 25.0 ab 45.1 an 5.0 ne 15.1 di 1.7 mt 4.2	Magdeberg, Hegau, Germany.	G. F. Föhr.	G. F. Föhr, In. Diss., Wurzburg, 1883, p. 32. R. T. 1884, p. liv.	Phonolite.	In W. T., p. 211, No. 40, miaskose.
SO_3 0.23 Cl 0.06 F trace Li_2O trace Cu 0.18	or 28.9 ab 35.6 an 3.6 ne 19.0 di 3.4 wo 2.3 mt 3.2	Staufen, Hegau.	G. F. Föhr.	G. F. Föhr, In. Diss., Wurzburg, 1883, p. 28. R. T. 1884, p. lii.	Phonolite.	In W. T., p. 211, No. 41, miaskose.
SO_3 0.41 Cl 0.08 F trace NiO trace Cu 0.12 Zn trace	or 20.6 ab 40.9 an 6.1 ne 18.5 no 2.6 di 3.4 wo 0.8 mt 2.8 il 0.5	Hohentwiel, Hegau.	G. F. Föhr.	G. F. Föhr, In. Diss., Wurzburg, 1883, p. 28. R. T. 1884, p. lii.	Phonolite.	In W. T., p. 213, No. 42, miaskose.
SO_3 0.46 Cl 0.07 Li_2O trace	or 20.6 ab 38.8 an 1.1 ne 27.8 di 4.4 wo 1.9 mt 3.0	Hohentwiel, Hegau.	Bernath.	Bernath, Btr. Kenntn. Phon. Hohentw., Berne, 1877, p. 41. R. T. 1879, p. lviii.	Phonolite.	Cf. Nos. 40–42, miaskose, W. T., p. 213.
	or 40.0 ab 21.5 an 3.6 ne 31.0 ol 2.9	Ditro, Siebenbürgen, Hungary.	Fellner.	Fellner, Vh. Wien., G. R.-A., 1867, p. 286. R. T. 1869, p. lx.	Ditroite.	Cf. No. 46, miaskose, W. T., p. 213.

SUBRANG 4. DOSODIC. VIEZZENOSE.

SO_3 0.57 Cl trace S trace	or 26.1 ab 33.5 an 10.0 ne 16.8 di 6.6 ol 2.9 mt 0.9 il 0.8	Campanario, Palma, Canary Islands.	Mardner.	Sauer, Unters. Phon. Gest. Canar., 1876, p. 60. R. T. 1879, p. lxvi.	Hornblende-andesite.	Calc. from sol. and insol.
SO_3 2.97 Cl 0.18	or 35.0 ab 7.9 an 15.3 ne 0.3 so 1.9 no 26.3 di 6.4 ol 2.6 mt 3.3	Sant' Antao, Cape Verde.	Kertscher.	C. Doelter, Die Capverden., 1882, p. 21. R. T. 1884, p. lxii.	Leucitophyre.	Near essexose.

CLASS I. PERSALANE.

RANG I. PERALKALIC. VARINGASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	68.54	9.49	8.60	3.23	0.42	0.54	3.14	5.11	0.30		1.36	trace		100.73	2.789
A2. II.	1.142	.093	.054	.044	.011	.010	.051	.054			.017	—			16°
2	70.30	6.32	9.23	1.40	0.89	0.84	7.70	2.50	0.82					100.00	2.69
A3. III.	1.172	.062	.057	.019	.022	.015	.124	.026							

RANG 2. DOMALKALIC.

1	72.32	13.37	0.57	2.34	3.57	1.88	2.76	2.30	0.68					99.79	
A3. III.	1.205	.131	.004	.032	.089	.034	.045	.024							

RANG 4. DOCALCIC.

1	66.88	11.69	1.68	8.94	3.55	5.45	1.25	0.20	1.03	trace		trace		100.67	
A3. III.	1.115	.115	.011	.124	.089	.097	.020	.002		—		—			

CLASS II. DOSALANE.

RANG 1. PERALKALIC. PANTELLERASE.

1	71.50	10.79	3.52	2.88	0.31	0.15	2.76	6.87	1.00	0.13	0.25		0.30	100.46	
A2. II.	1.192	.106	.022	.040	.008	.003	.045	.073			.003		.004		

RANG 1. PERALKALIC. PANTELLERASE.

1	65.80	12.80	6.64	0.18	1.78	2.92	4.16	4.40	1.20					99.88	
A3. III.	1.097	.125	.041	.003	.045	.052	.067	.047							
2	68.75	11.40	4.30	3.30	1.46	1.24	5.37	4.22	0.30		in SiO_2		trace	100.34	
A3. III.	1.146	.112	.027	.046	.087	.022	.087	.045					—		
3	69.61	8.02	7.17	2.83	0.65	0.88	7.47	2.88	0.74					100.25	2.44
A3. III.	1.160	.078	.045	.039	.016	.016	.120	.031							
4	69.02	10.09	4.42	4.56	0.76	1.45	6.29	3.70	n. d.					100.58	2.46
A3. III.	1.150	.099	.027	.063	.019	.026	.101	.039							
5	68.33	10.94	3.74	5.41	0.16	1.36	7.09	4.08	n. d.					101.36	2.48
B3. IV.	1.139	.107	.023	.075	.004	.024	.115	.044							

ORDER 3. QUARFELIC. HISPANARE.

SUBRANG 3. SODIPOTASSIC. VARINGOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
Cl trace CuO trace	Q 31.0 ac 5.5 or 30.0 di 2.2 ab 20.4 mt 6.3 il 2.6 hm 2.4	Altendiez, Nassau.	Senftner.	J. Petersen, N. J., 1872, p. 593. R. T. 1873, p. XII.	Felsite-porphyry.	
	Q 29.1 ac 26.2 or 14.5 ns 3.9 ab 18.9 di 3.5 hy 3.1	Khartibugal, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 173, 1884. R. T. 1884, p. LXVI.	Pantellerite.	In W. T., p. 219, No. 4, varingose.

SUBRANG 4. DOSODIC.

	Q 36.4 hy 12.6 or 13.3 mt 0.9 ab 23.6 an 9.5 C 2.9	Fabbiasco, n. Lugano, Piedmont.	Slaytor.	T. Harada, N. J. B. B., II, p. 42, 1883. R. T. 1884, p. XVIII.	Felsophyre.	Alkalies low?

SUBRANG 4,5. PRESODIC.

	Q 35.5 di 0.9 or 1.1 hy 23.4 ab 10.5 mt 2.6 an 25.9	Little Falls, Minnesota.	Streng.	Streng, N. J., 1877, p. 230. R. T. 1879, p. XXXVI.	Quartz-diorite.	

ORDER 4. QUARDOFELIC. AUSTRARE.

SUBRANG 2. DOPOTASSIC.

	Q 28.2 ac 5.5 or 40.6 di 0.7 ab 17.3 hy 4.0 mt 2.3 il 0.5	Monte Mufetto, Serimando Valley, Bergamask Alps.	Gümbel.	Gümbel, Sb. Münch. Ak., 1880, p. 189. R. T. 1884, p. XVIII.	Felsite-porphyry.	Near omeose.

SUBRANG 3. SODIPOTASSIC. GRORUDOSE.

	Q 18.5 di 8.9 or 26.1 hy 0.4 ab 35.1 mt 0.7 an 3.1 hm 6.1	Urrismenagh, County Donegal, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac., XXIV, 1866. R. T. 1869, p. XLVI.	Granite.	Iron oxides?
	Q 17.8 ac 9.2 or 25.0 di 5.1 ab 35.1 hy 6.3 mt 1.6	Balduinstein, Hesse-Nassau.	Gümbel.	Gümbel, Sb. Münch. Ak., 1882, p. 210. R. T. 1884, p. XVI.	Felsite-porphyry.	
	Q 24.8 ac 20.8 or 17.2 ns 3.5 ab 24.6 di 3.8 hy 4.8	Khartibugal, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 173, 1884. R. T. 1884, p. LXVI.	Pantellerite.	In W. T., p. 224, No. 7, grorudose.
CuO 0.29	Q 19.6 ac 12.1 or 21.7 ns 1.7 ab 31.4 di 6.3 hy 7.0	Cuddia Mida, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 182, 1884. R. T. 1884, p. LXVI.	Pantellerite.	In W. T., p. 221, No. 8, grorudose.
CuO 0.25	Q 14.5 ac 10.6 or 24.5 ns 4.9 ab 33.0 di 6.0 hy 7.1	Khania, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 170, 1884. R. T. 1884, p. LXVI.	Pantellerite.	Not in W. T.

CLASS II. DOSALANE—Continued.

RANG 1. PERALKALIC. PANTELLERASE—Continued.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp. gr.
1	65.93	11.33	4.65	4.69	1.10	2.36	4.58	3.44	1.83					99.91	
A3. III	1.099	.111	.029	.065	.028	.042	.074	.036							
2	67.89	11.53	4.51	4.52	0.62	1.51	5.79	3.71	0.33					100.41	2.43
A3. III	1.132	.113	.028	.062	.016	.027	.093	.039							
3	67.48	9.70	7.42	2.21	0.77	1.45	7.21	2.94	0.96					100.14	2.68
A3. III	1.125	.095	.046	.030	.019	.026	.116	.031							
4	67.18	14.18	4.00	2.48	0.34	2.78	5.89	4.01	—					100.86	2.40
A3. III	1.120	.139	.025	.035	.009	.050	.095	.043							
RANG 2. DOMALKALIC. DACASE.															
1	61.93	13.18	3.63	2.31	4.59	3.48	2.67	6.11	1.14					99.04	
B3. IV	1.032	.129	.023	.032	.115	.063	.044	.065							
2	64.94	17.50	0.69	3.94	2.83	2.59	3.44	3.11	1.36					100.40	2.72
A3. III	1.082	.171	.004	.055	.071	.046	.055	.033							
3	64.65	14.13	5.24	3.02	1.41	1.65	2.78	5.26	1.97	0.29	0.50		trace	100.90	2.659
A2. II	1.078	.138	.033	.042	.035	.030	.045	.056			.006		—		
4	66.57	15.59	0.37	4.25	1.88	1.85	3.69	5.27	0.62	trace	trace	trace		100.09	2.637
A3. III	1.110	.152	.002	.059	.047	.033	.060	.056			—	—			
RANG 2. DOMALKALIC. DACASE.															
1	65.27	15.76	1.36	3.44	2.14	3.70	4.57	3.97	0.42			0.26		100.89	
A3. III	1.088	.154	.009	.048	.054	.066	.074	.043				.002			
2	56.59	12.41	5.39	10.28	2.02	6.70	4.27	1.02	1.45	trace	0.22	0.44		100.79	
A2. II	.943	.122	.034	.143	.051	.120	.069	.012			.003	.003			
3	63.49	12.42	6.41	1.34	1.32	4.17	4.90	1.78	2.88			trace	0.85	99.56	2.52
A3. III	1.058	.121	.040	.018	.033	.075	.079	.019				—	.012		15°
4	64.39	15.99	1.47	5.98	1.67	2.57	4.96	2.46	0.76			trace	trace	99.25	
B3. IV	1.073	.156	.009	.083	.042	.046	.080	.027							
5	67.74	13.04	4.48	3.81	1.01	3.08	4.80	1.55	0.88					100.39	
A3. III	1.129	.128	.028	.053	.025	.055	.077	.017							
6	70.17	11.10	1.92	2.86	1.23	3.34	3.77	3.23	1.87					99.49	
A3. III	1.170	.109	.012	.040	.031	.060	.061	.034							
7	60.78	16.90	4.79	4.11	2.89	1.50	4.01	2.69	2.84					100.51	2.698
A3. III	1.013	.166	.030	.057	.072	.027	.065	.029							

ORDER 4. QUARDOFELIC. AUSTRARE—Continued.

SUBRANG 4. DOSODIC. PANTELLEROSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 19.9 di 9.6 or 20.0 hy 2.7 ab 38.8 mt 6.7 an 0.3	Yxsta, Sect. Örebro, Sweden.	Hasselbom.	Gumälius, Sv. G. Und., XLVIII, p. 18, 1873. R. T. 1879, p. XIV.	Granite.	
	Q 16.9 ac 8.8 or 21.7 di 6.5 ab 38.8 hy 5.3 mt 2.1	Monte San Elmo, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 186, 1884. R. T. 1884, p. LXVI.	Pantellerite.	In W. T., p. 221, No. 3, pantellerose.
	Q 17.4 ac 21.3 or 17.2 ns 0.8 ab 33.5 di 6.2 hy 2.8	Monte San Elmo, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 186, 1884. R. T. 1884, p. LXVI.	Pantellerite.	In W. T., p. 221, No. 4, pantellerose.
	Q 13.3 di 4.4 or 23.9 wo 3.5 ab 49.8 mt 5.8 an 0.3	Cala Porticello, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 133, 1883. R. T. 1884, p. L.	Liparite.	Not in W. T
SUBRANG 3. SODIPOTASSIC. ADAMELLOSE.						
	Q 10.3 di 9.4 or 36.1 hy 8.3 ab 23.1 mt 5.3 an 5.6	Laveline, Vogesen,	van Werveke.	H. Rosenbusch, N. J., 1881, I, p. 235. R. T. 1884, p. XIV.	Granite.	
	Q 21.0 hy 13.8 or 18.4 mt 0.9 ab 28.8 an 12.8 C 3.8	Lippenhof, n. Tryberg, Schwarzwald, Baden.	Gattermann?	G. H. Williams, N. J. B. B., II, p. 624, 1883. R. T. 1884, p. XXX.	Quartz-diorite-porphyry.	Near dacase, cf. No. 12, adamellose, W. T., p. 223.
	Q 22.4 hy 3.9 or 31.1 mt 7.7 ab 23.6 il 0.9 an 8.3 C 0.7	Corällchen, n. Liebenstein, Thuringia.	G. Pringsheim.	G. Pringsheim, Z. D. G. G., XXXII, p. 144, 1880. R. T. 1884, p. XVI.	Granite-porphyry.	Near toscanose.
CuO trace	Q 14.6 hy 12.2 or 31.1 mt 0.5 ab 31.4 an 9.2 C 0.3	Kirche Wange, Silesia.	O. Jung.	O. Jung, Z. D. G. G., XXXV, p. 830, 1883. R. T. 1884, p. XVI.	Granite-porphyry.	Near toscanose.
SUBRANG 4. DOSODIC. DACOSE.						
	Q 11.6 di 6.7 or 23.9 hy 6.8 ab 38.8 mt 2.0 an 10.3	Watab, Minnesota.	Streng.	Streng, N. J., 1877, p. 230. R. T. 1879, p. XXXVI.	Quartz-diorite.	Near adamellose.
	Q 8.8 di 16.4 or 6.7 hy 11.1 ab 36.2 mt 7.9 an 11.4 ap 1.0	Sauk Center, Minnesota.	Streng.	Streng, N. J., 1877, p. 227. R. T. 1879, p. XXXIV.	Quartz-diorite.	Near III, 4, 2, 4.
SO_3 trace Cl trace Cu trace	Q 20.3 di 7.2 or 10.6 wo 2.2 ab 41.4 mt 4.2 an 6.4 hm 3.5	Yate Volcano, Patagonia.	H. Ziegenspeck.	H. Ziegenspeck, In. Diss., Jena, 1883, p. 46. R. T. 1884, p. LXXII.	Augite-andesite.	In W. T., p. 227, No. 11, dacose.
	Q 12.2 hy 14.0 or 15.0 mt 2.1 ab 41.9 an 12.8 C 0.3	Peterhead, Scotland.	A. Phillips.	A. Phillips, Q. J. G. S., XXXVI, p. 13, 1880. R. T. 1884, p. XIV.	Segregation in granite.	Cf. No. 10, toscanose.
	Q 25.6 di 4.9 or 9.5 hy 3.4 ab 40.4 mt 6.5 an 9.5	Finaker, Sect. Linde, Sweden.	Hummel.	Hummel, Sv. G. Und., XLVII, p. 16, 1873. R. T. 1879, p. XIV.	Granite.	
	Q 28.0 di 10.6 or 18.9 hy 1.5 ab 32.0 mt 2.8 an 3.9	Klausen, Vildarthal, Tyrol.	von John?	Teller and von John, Jb. Wien. G. R-A., XXXII, p. 653, 1882. R. T. 1884, p. XXVIII.	Quartz-diorite.	
	Q 17.8 hy 10.8 or 16.1 mt 7.0 ab 34.1 an 7.5 C 4.6	Suldenferner, Mte. Cevedale, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 403, 1879. R. T. 1884, p. XXXIV.	Quartz-porphyrite.	

CLASS II. DOSALANE—Continued.

RANG 3. ALKALICALCIC. TONALASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	57.88	15.20	7.50	1.35	6.34	4.81	2.67	3.03	1.04					99.82	
A3. III	.965	.149	.047	.019	.159	.086	.044	.032							
2	56.32	18.26	3.70	4.28	4.15	6.13	2.37	2.67	2.22					100.10	
A3. III	.939	.179	.023	.060	.104	.109	.039	.029							
3	62.75	17.11	2.20	5.61	0.77	4.57	2.57	4.41	0.50					100.49	
A3. III	1.046	.168	.014	.078	.019	.082	.042	.047							
4	57.02	16.52	3.25	6.27	2.42	8.64	2.38	2.54	1.28					100.32	2.703
A3. III	.950	.162	.020	.088	.061	.154	.039	.027							

RANG 3. ALKALICALCIC. TONALASE.

1	60.32	16.92	5.88	1.40	3.52	5.64	3.83	2.42	0.44					100.37	
A3. III	1.005	.166	.036	.019	.087	.101	.061	.025							
1	59.97	16.93	2.41	4.83	3.61	5.10	3.87	1.32	1.60					99.64	
A3. III	1.000	.166	.015	.067	.090	.091	.063	.014							
2	59.95	17.35	1.44	5.59	2.88	6.75	3.30	2.08	1.42					100.76	2.776
A3. III	.999	.170	.009	.078	.072	.121	.053	.022							
3	56.85	16.70	5.92	7.13	3.25	5.97	2.78	1.91	0.54					101.05	
B3. IV	.948	.164	.037	.099	.081	.107	.045	.020							
4	58.01	18.19	3.40	2.89	3.01	7.55	3.92	1.39	1.60					99.96	
A3. III	.967	.178	.021	.040	.075	.135	.063	.015							

RANG 4. DOCALCIC. BANDASE.

1	52.02	17.14	7.96	3.52	3.13	11.57	2.38	0.60	0.28			trace	trace	99.45	2.76
A3. III	.867	.168	.050	.049	.078	.207	.039	.006				—	—		16°
2	56.20	15.26	7.74	5.09	3.21	9.50	2.70	0.62	—					100.32	
A3. III	.937	.150	.048	.071	.080	.170	.044	.006							
3	61.37	15.76	4.06	2.94	2.86	7.27	3.04	0.71	2.64					100.65	2.72
A3. III	1.023	.154	.026	.041	.072	.130	.049	.008							
4	57.82	18.00	2.15	3.47	3.16	11.90	2.34	0.97	1.03					100.84	
A3. III	.964	.176	.014	.049	.079	.213	.038	.010							

ORDER 4. QUARDOFELIC. AUSTRARE—Continued.

SUBRANG 3. SODIPOTASSIC. HARZOSE.

Inclusive.	Norm.		Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 11.5 or 17.8 ab 23.1 an 20.3	di 2.8 hy 14.6 mt 4.4 hm 4.5	West Aston, County Wicklow, Ireland.	S. Haughton	S. Haughton, Tr. R. Ir. Ac., XXIII, p. 619, 1859. R. T. 1869, p. LXIV.	Greenstone (diorite).	Iron oxides? Cf. No. 2, shoshonose.
	Q 10.3 or 16.1 ab 20.4 an 30.8 C 0.2	hy 15.3 mt 5.3	Gäddviken, Animskogssocken, Sweden.	Törnebohm.	Törnebohm, Sv. G. Und., XXXIV, p. 31, 1870. R. T. 1873, p. XVIII.	Diorite.	Near II. 5. 4. 3.
	Q 16.1 or 26.1 ab 22.0 an 22.0	di 0.7 hy 9.9 mt 3.3	Launa Körkia, Island Hochland, Finland.	Lemberg.	Lemberg, Arch. Nk. Livl., IV, p. 179, 1867. R. T. 1869, p. LXIV.	Labradorite-porphyry (diorite).	
	Q 10.5 or 15.0 ab 20.4 an 26.7	di 13.5 hy 8.3 mt 4.6	Hintere Gratspitze, Mte. Cevedale, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 395, 1879. R. T. 1884, p. XXXIV.	Suldenite.	

SUBRANG 4. DOSODIC. TONALOSE.

Inclusive.	Norm.		Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 13.3 or 13.9 ab 32.0 an 22.2	di 4.5 hy 6.6 mt 4.4 hm 2.7	Hac. de Chuquipoyo, Chimborazo, Ecuador.	A. Schwager.	Gümbel, Sb. Münch. Ak., 1881, p. 348. R. T. 1884, p. LXX.	Andesite.	In W. T., p. 239. No. 77, tonalose.
	Q 13.1 or 7.8 ab 33.0 an 24.7	di 0.4 hy 15.4 mt 3.5	Vildarthal, Tyrol.	von John?	Teller and von John, Jb. Wien. G. R-A., XXXII, p. 653, 1882. R. T. 1884, p. XXVIII.	Quartz-norite.	
	Q 11.5 or 12.2 ab 27.8 an 26.4	di 6.0 hy 13.3 mt 2.1	Lienz, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 400, 1879. R. T. 1884, p. XXXII.	Porphyrite.	
	Q 12.5 or 11.1 ab 23.6 an 27.5	di 1.8 hy 15.4 mt 8.6	Tinnebach, Tyrol.	von John?	Teller and von John, Jb. Wien. G. R-A., XXXII, p. 653, 1882. R. T. 1884, p. XXVIII.	Norite-porphyry.	
	Q 10.2 or 8.3 ab 33.0 an 27.8	di 7.7 hy 6.4 mt 4.9	Hajto, n. Nagyag, Siebenbürgen.	C. Doelter.	C. Doelter, T. M. P. M., 1873, p. 95. R. T. 1879, p. LXIV.	Dacite.	Near andose.

SUBRANG 4,5. PRESODIC. BANDOSE.

Inclusive.		Norm.		Locality.	Analyst.	Reference.	Author's name.	Remarks.
SO_3 Cl	trace trace	Q 11.3 or 3.3 ab 20.4 an 34.2	di 16.9 wo 0.8 mt 11.5	Portañuela, Yate Volcano, Patagonia.	H. Ziegenspeck.	H. Ziegenspeck, In. Diss., Jena., 1883, p. 29. R. T. 1884, p. LXXIV.	Basalt.	In W. T., p. 249, No. 14, bandose.
		Q 15.8 or 3.3 ab 23.1 an 27.8	di 15.6 hy 3.6 mt 11.1	Stransko, n. Liebstadt, Bohemia.	Werther.	Werther, Jb. Pr. Chem., XCI, p. 330, 1864. R. T. 1869, p. LXXVIII.	Melaphyre.	Cf. No. 9, andose.
		Q 22.0 or 4.5 ab 25.7 an 27.0	di 7.3 hy 5.7 mt 6.0	St. Egidi, Styria.	Niedzwiedki.	Niedzwiedki, T. M. P. M., 1872, p. 255. R. T. 1873, p. XLVIII.	Pitchstone.	
		Q 13.3 or 5.6 ab 19.9 an 35.6	di 19.3 hy 3.1 mt 3.3	Suldenferner, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 341, 1879. R. T. 1884, p. XXX.	Diorite-porphyry.	

CLASS II. DOSALANE—Continued.

RANG 1. PERALKALIC. UMPTEKASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	61.86	16.58	2.17	6.39	0.54	0.28	4.98	5.34	1.95	0.30	0.10	0.11	trace	100.72	2.701
A2. II	1.031	.162	.014	.089	.014	.005	.081	.056			.001	.001	—		

RANG 1. PERALKALIC. UMPTEKASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	63.69	15.03	2.51	2.41	0.80	3.30	6.54	2.46	2.23			trace	0.55	99.52	2.55
A3. III	1.062	.147	.015	.033	.020	.059	.105	.026				—	.008		15°

RANG 2. DOMALKALIC. MONZONASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	52.14	15.37	6.83	3.35	6.62	6.54	3.38	4.43	2.15					100.81	
A3. III	.869	.150	.043	.047	.166	.117	.055	.047							
2	57.73	17.85	4.44	3.90	1.77	3.65	3.77	7.65	0.09			trace		100.85	2.61
A3. III	.962	.175	.028	.054	.044	.065	.061	.082				—			

RANG 2. DOMALKALIC. MONZONASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	59.62	18.81	2.03	2.99	1.92	5.13	5.65	2.68	1.04					99.84	
A3. III	.994	.183	.013	.042	.048	.091	.091	.029							
2	57.89	16.82	5.61	2.83	3.51	3.01	5.87	2.96	1.38		0.57		0.14	100.59	2.779
A2. II	.965	.165	.035	.039	.088	.054	.095	.032			.007		.002		
3	51.42	16.52	6.64	4.42	4.62	6.48	4.72	3.46	1.82		0.64			100.74	2.722
A2. II	.857	.162	.042	.061	.116	.116	.076	.037			.008				
4	52.85	13.70	6.91	7.32	2.88	7.00	4.23	2.74	1.98					99.61	2.796
A3. III	.881	.134	.043	.102	.072	.125	.068	.029							
5	56.02	16.52	5.02	5.51	4.67	4.20	5.83	1.66	0.47				0.36	100.26	
A3. III	.934	.162	.031	.076	.117	.075	.093	.018					.005		

RANG 3. ALKALICALCIC. ANDASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	56.51	19.61	5.10	0.98	2.66	7.89	3.12	3.67	0.40				0.11	100.05	2.50
A3. III	.942	.192	.032	.014	.067	.141	.050	.039					.002		
2	52.08	15.60	5.75	2.57	8.40	6.52	2.92	3.80	2.24					99.88	
A3. III	.868	.153	.036	036	.210	.116	.047	.040							
3	54.65	15.72	2.00	6.26	5.91	7.83	2.90	3.79	1.90			trace	trace	100.96	2.864
A3. III	.911	.154	.013	.087	.148	.139	.047	.040							

ORDER 5. PERFELIC. GERMANARE.

SUBRANG 3. SODIPOTASSIC. ILMENOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
SO$_3$ 0.12	Q 6.6 or 31.1 ab 42.4 an 1.4 C 2.0 hy 11.3 mt 3.3	Ortberg, n. Elbingerode, Harz Mountains.	Jacobs.	K. A. Lossen, Sb. Ges. Nat. Fr., 1883, p. 178. R. T. 1884, p. xxii.	Keratophyre.	

RANG 4. DOSODIC. UMPTEKOSE.

SO$_3$ trace Cl trace Cu trace	Q 9.8 or 14.5 ab 55.0 an 4.4 di 9.4 mt 3.5	Yate Volcano, Patagonia.	H. Ziegenspeck.	H. Ziegenspeck, In. Diss., Jena., 1883, p. 42. R. T. 1884, p. lxxii.	Andesite.	In W. T., p. 253, No. 4, umptekose near pantellerose and kallerudose.

SUBRANG 3. SODIPOTASSIC. MONZONOSE.

	or 26.1 ab 25.2 an 13.3 ne 2.0 di 14.9 ol 7.2 mt 10.0	Wehling, n. Heidelberg, Rhenish Prussia.	Nietzsche.	Beneke and Cohen, Geog. Besch. Heidelb., 1879, p. 93. R. T. 1879, p. xxiv.	Syenite.	
	or 45.6 ab 26.2 an 8.9 ne 3.1 di 7.6 ol 3.0 mt 6.5	L'Arso, Ischia.	C. W. C. Fuchs.	C. W. C. Fuchs, T. M. P. M., 1872. p. 230. R. T. 1873, p. xxxviii.	Trachyte.	Cf. No. 40, monzonose, W. T., p. 259.

SUBRANG 4. DOSODIC. AKEROSE.

	Q 2.6 or 16.1 ab 47.7 an 17.5 di 6.4 hy 5.5 mt 3.0	Busholm, Sweden.	Törnebohm.	Hummel and Erdmann, Sv. G. Und., XXXIV, p. 27, 1870. R. T. 1873, p. x.	Granite.	
	Q 1.4 or 17.8 ab 49.8 an 10.6 di 3.5 hy 7.2 mt 7.4 il 1.1 hm 0.5	Barr-Andlau, Vogesen.	Unger.	H. Rosenbusch, Steig. Schiefer., 1877, p. 154. R. T. 1879, p. xiv.	Segregation in granite.	Cf. No. 2, amiatos .
	or 20.6 ab 28.8 an 13.6 ne 5.9 di 14.6 ol 4.4 mt 9.7 il 1.2	Hopfenberg, n. Schwarzenfels, Rhöngebirge.	Möhl.	Möhl, N. J., 1874, p. 906, R. T. 1879, p. lxxii.	Basalt.	
	Q 0.4 or 16.1 ab 35.6 an 10.3 di 20.4 hy 4.8 mt 10.0	Suldenferner, Monte Cevedale, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 368, 1879. R. T. 1884, p. xxxii.	Ortlerite.	
	or 10.0 ab 48.7 an 14.2 di 5.3 hy 10.8 ol 3.1 mt 7.2	Taal Volcano, Luzon, Philippines.	K. Oebbeke.	K. Oebbeke, N. J. B. B. I., p. 482, 1881. R. T. 1884, p. lxx.	Augite-andesite.	

SUBRANG 3. SODIPOTASSIC. SHOSHONOSE.

Li$_2$O trace	Q 5.8 or 21.7 ab 26.2 an 28.6 di 8.2 hy 2.9 mt 3.3 hm 2.9	Truckee Canyon, Purple Hills, Nevada.	R. W. Woodward.	C. King, G. Expl. 40th Par., II, p. 833, 1877. R. T. 1879, p. lviii.	Trachyte.	
	or 22.2 ab 24.6 an 18.4 di 10.8 hy 6.8 ol 6.4 mt 8.3	West Aston, County Wicklow, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac., XXIII, p. 619, 1859. R. T. 1869, p. lxiv.	Greenstone (diorite).	Cf. No. 1, harzose.
Cl trace S trace	or 22.2 ab 24.6 an 18.6 di 16.3 hy 8.0 ol 6.3 mt 3.0	Hohne, Harz Mountains.	Keibel.	Keibel, Z. D. G. G., IX, p. 575, 1857. R. T. 1869, p. lviii.	Diorite (syenite).	

CLASS II. DOSALANE—Continued.

RANG 3. ALKALICALCIC. ANDASE—Continued.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp. gr.
4	53.73	18.22	5.83	6.32	1.62	7.00	2.76	2.83	1.68					99.99	2.765
A3. III	.896	.178	.036	.088	.041	.125	.045	.030							
5	48.95	14.80	8.42	10.23	2.08	7.40	3.23	2.97	1.76					99.84	2.832
A3. III	.816	.145	.053	.142	.052	.132	.052	.032							
6	55.35	17.51	3.39	7.61	1.45	6.36	3.51	3.45	1.82					100.45	2.794
A3. III	.923	.172	.021	.106	.036	.114	.056	.037							
7	54.48	19.44	1.80	4.90	3.72	7.08	3.58	3.32	1.70					100.02	
A3. III	.908	.190	.011	.068	.093	.127	.058	.035							

RANG 3. ALKALICALCIC. ANDASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp. gr.
1	56.19	16.12	4.92	4.43	4.60	7.00	2.96	2.37	1.03			0.27	trace	99.91	2.742
A3. III	.937	.158	.031	.061	.115	.125	.048	.025				.002	—		
2	49.04	18.11	2.71	7.70	4.72	7.11	4.22	2.11	1.29		2.46			99.42	2.80
B2. III	.817	.177	.017	.107	.118	.127	.068	.022			.031				
3	54.52	19.10	2.83	5.89	3.92	7.25	3.73	2.30	0.59		trace			100.13	2.6— 2.7
A3. III	.909	.187	.018	.082	.098	.130	.060	.024			—				
4	53.94	17.05	2.93	7.15	4.67	7.41	3.45	2.19	1.10				trace	99.89	2.6— 2.7
A3. III	.899	.167	.018	.099	.117	.132	.056	.023					—		
5	58.45	17.08	0.76	4.61	5.15	7.60	4.25	1.02				trace	trace	99.99	2.94
A3. III	.974	.167	.005	.064	.129	.136	.069	.011				—	—		
6	54.89	15.16	3.05	5.08	5.79	7.94	3.24	2.32	1.80					99.27	
B3. IV	.915	.148	.019	.071	.145	.142	.052	.024							
7	54.68	15.52	2.70	5.32	4.22	9.82	3.27	2.13	1.94					99.60	
A3. III	.911	.152	.017	.074	.106	.175	.053	.022							
8	55.10	15.72	3.23	5.40	6.48	7.73	3.19	1.20	1.45	0.50		trace		100.00	
A3. III	.918	.154	.020	.075	.162	.138	.052	.013				—			
9	51.69	15.72	3.25	6.80	4.85	9.38	3.90	1.05	1.42	0.87	1.51		trace	100.44	2.931
A3. III	.862	.154	.020	.094	.121	.168	.063	.011			.019				15°
10	53.18	18.43	6.46	3.46	4.55	6.85	3.05	2.56	1.98			trace		100.52	2.842
A3. III	.886	.180	.040	.048	.114	.122	.049	.028							
11	61.80	16.70	3.28	3.89	1.87	6.60	3.97	2.08	0.09					100.28	2.764
A3. III	1.030	.162	.021	.054	.047	.118	.079	.022							

ORDER 5. PERFELIC. GERMANARE—Continued.

SUBRANG. SODIPOTASSIC. SHOSHONOSE—Continued.

Inclusive.	Norm.		Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 7.4 or 16.7 ab 23.6 an 28.6	di 5.1 hy 8.4 mt 8.4	Plimabach, Monte Cevedale, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 371, 1879. R. T. 1884, p. XXXII.	Ortlerite.	
	or 17.8 ab 27.3 an 17.0	di 16.8 hy 3.1 ol 4.0 mt 12.3	Gratspitze, Monte Cevedale, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 362, 1879. R. T. 1884, p. XXXII.	Ortlerite.	
	Q 3.1 or 20.6 ab 29.3 an 22.0	di 9.3 hy 10.6 mt 4.9	S. of Zehnerkopf, Wildkaar, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXVII, p. 227, 1877. R. T. 1879, p. XLIV.	Proterobase.	
	or 19.5 ab 30.4 an 27.0	di 6.8 hy 8.2 ol 3.9 mt 2.6	Limansua, Island Leyte, Philippines.	K. Oebbeke	K. Oebbeke, N. J. B. B., I, p. 461, 1881. R. T. 1884, p. LXVIII.	Hornblende-andesite.	Near andose.

SUBRANG 4. DOSODIC. ANDOSE.

Inclusive.	Norm.		Locality.	Analyst.	Reference.	Author's name.	Remarks.
Cl 0.02	Q 8.6 or 13.9 ab 25.2 an 23.6	di 9.0 hy 11.0 mt 7.2	**Buffalo Peak, Colorado.**	**W. F. Hillebrand.**	W. Cross, A. J. S., XXV, p. 142, 1883. R. T. 1884, p. LXXII.	Andesite.	**In W. T., p. 277, No. 35, andose.**
	or 12.2 ab 24.6 an 29.9 ne 3.1	di 9.1 ol 11.1 mt 3.9 il 4.7	**Buffalo Peak, North Park, Colorado.**	R. W. Woodward.	C. King, G. Expl., 40th par., II, p. 126, 1877. R. T. 1879, p. LXXIV.	**Basalt.**	
	Q 1.0 or 13.3 ab 31.4 an 28.6	di 6.2 hy 14.3 mt 4.2	**Diabase Hills, Truckee Range, Nevada.**	R. W. Woodward..	C. King, G. Expl., 40th par., II, p. 574, 1877. R. T. 1879, p. XLII.	**Diabase.**	
	Q 0.4 or 12.8 ab 29.3 an 24.5	di 10.1 hy 17.4 mt 4.2	Diabase Hills, Truckee Range Nevada.	R. W. Woodward.	C. King, G. Expl., 40th par., II, p. 812, 1877. R. T. 1879, p. LXXIV.	**Basalt.**	
	Q 5.0 or 6.1 ab 36.2 an 24.2	di 11.1 hy 15.3 mt 1.2	Pen Maen Mawr Wales.	Phillips.	Phillips, Q. J. G. S., XXXIII, p. 424, 1877. R. T. 1879, p. XXXIV.	Diorite.	
	Q 2.8 or 13.3 ab 27.3 an 20.0	di 15.7 hy 13.8 mt 4.4	Langviksuäs, Animskogssocken, Sweden.	Törnebohm.	Törnebohm, Sv. G. Und., XXXIV, p. 31, 1870. R. T. 1873, p. XVIII.	Diorite.	
	Q 2.8 or 12.2 ab 27.8 an 21.4	di 22.2 hy 7.3 mt 3.9	N. of Myran, Animskogssocken, Sweden.	Törnebohm.	Törnebohm, Sv. G. Und., XXXIV, p. 31, 1870. R. T. 1873, p. XVIII.	Diorite.	
Li_2O trace Rb_2O trace Cs_2O trace	Q 50.4 or 7.2 ab 27.3 an 24.7	di 11.0 hy 18.1 mt 4.6	Bet. Konken and Herchweiler, Palatinate.	Laspeyres.	Laspeyres, Vh. Nh. Ver. Bonn., X, p. 381, 1883. R. T. 1884, p. XLVI.	Melaphyre.	
	or 6.1 ab 33.0 an 22.2	di 20.0 hy 8.3 ol 0.1 mt 4.6 il 2.9	Dietesheim, Mainthal.	Hornstein.	Hornstein, Z. D. G. G., XIX, p. 341, 1867. R. T. 1869, p. CXXXII.	Anamesite.	Near camptonose.
	Q 4.6 or 15.6 ab 25.7 an 28.6	di 4.2 hy 10.5 mt 9.3	Stransko, n. Liebstadl, Bohemia.	Mikula.	G. Tschermak, Vh. Wien. G. R-A., 1867, p. 52. R. T. 1869, p. LXXVIII.	Melaphyre.	Cf. No. 1, bandose.
	Q 10.0 or 12.2 ab 41.4 an 17.0	di 13.1 hy 2.4 mt 4.9	Suldenferner, Monte Cevedale, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 403, 1879. R. T. 1884, p. XXXIV.	Quartz-porphyrite.	**Near harzose, tonalose, and shoshonose.**

CLASS II. DOSALANE—Continued.

RANG 3. ALKALICALCIC. ANDASE—Continued.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
12	55.15	17.92	2.82	3.82	2.86	11.30	3.25	1.28	2.49					100.89	2.731
A3. III	.919	.175	.018	.053	.072	.202	.053	.014							
13	55.05	17.16	5.19	5.01	2.47	8.30	3.79	2.84	1.23					101.04	2.764
B3. IV	.918	.168	.033	.069	.062	.148	.061	.030							
14	54.90	16.32	6.52	5.81	1.66	6.80	3.87	1.61	2.47					99.86	2.775
A3. III	.915	.160	.041	.081	.042	.121	.063	.017							
15	57.85	17.32	4.38	5.19	2.97	7.08	4.02	1.23	0.98					101.02	2.706
B3. IV	.964	.170	.028	.072	.074	.127	.065	.013							
16	55.80	17.20	5.22	7.13	2.76	6.97	3.62	1.23	1.23					101.16	
B3. IV	.930	.169	.033	.099	.069	.125	.058	.013							
17	55.18	16.80	1.93	10.37	2.62	6.90	3.20	2.42	1.63					101.05	2.818
B3. IV	.920	.165	.012	.144	.066	.123	.052	.026							
18	54.55	15.15	4.62	10.42	2.93	6.06	4.25	1.20	1.97					101.15	2.828
B3. IV	.909	.148	.029	.144	.073	.108	.069	.013							
19	51.75	18.96	2.34	10.42	3.25	6.84	3.45	1.93	1.23					100.17	2.837
A3. III	.863	.186	.014	.144	.081	.122	.056	.021							
20	48.18	18.86	2.27	6.22	8.46	9.95	3.88	1.23	0.45		trace	0.37	trace	99.87	2.954
A3. III	.803	.185	.014	.086	.212	.178	.063	.013			—	.003	—		
21	49.27	18.54	6.98	5.62	3.76	10.38	3.45	2.22	—					100.36	2.738
A3. III	.821	.182	.044	.078	.094	.186	.056	.023							
22	49.24	19.06	1.77	10.33	5.00	8.75	3.89	1.19	0.63					99.86	
A3. III	.821	.186	.011	.143	.125	.156	.063	.013							
23	58.42	17.64	5.66	4.00	2.54	4.50	4.44	2.52	0.42		0.31		0.48	100.93	
B2. III	.974	.173	.036	.056	.064	.080	.072	.027			.004		.007		
24	54.62	16.96	4.50	4.27	5.20	8.56	3.26	1.80	0.73		trace		.035	100.25	
A3. III	.910	.166	.028	.060	.130	.153	.053	.019			—		.005		
25	53.39	15.23	8.73	3.61	4.12	8.46	3.60	1.84	1.14	0.22		0.16		100.66	2.814
A2. II	.890	.149	.054	.050	.103	.151	.058	.020				.001			

ORDER 5. PERFELIC. GERMANARE—Continued.

SUBRANG 4. DOSODIC. ANDOSE—Continued.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 6.0 di 21.3 or 7.8 hy 1.4 ab 27.8 mt 4.2 an 30.0	Suldenferner, Monte Cevedale, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 395, 1879. R. T. 1884, p. xxxiv.	Suldenite.	
	Q 2.9 di 16.0 or 16.7 hy 3.2 ab 32.0 mt 7.7 an 21.4	Near Schaubach, Monte Cevedale, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 395, 1879. R. T. 1884, p. xxxiv.	Suldenite.	
	Q 9.1 di 9.5 or 9.5 hy 4.7 ab 33.0 mt 9.5 an 22.2	Suldenferner, Monte Cevedale, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 395, 1879. R. T. 1884, p. xxxii.	Suldenite.	Near tonalose.
	Q 9.5 di 8.0 or 7.2 hy 9.3 ab 34.1 mt 6.5 an 25.6	Pradaccio, Valforno, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXIX, p. 341, 1879. R. T. 1884, p. xxx.	Diorite.	Near tonalose.
	Q 8.6 di 6.3 or 7.2 hy 12.8 ab 30.4 mt 7.7 an 27.2	Tinnebach, Tyrol.	von John.	Teller and von John, Jb. Wien. G. R-A., XXXII, p. 653, 1882. R. T. 1884, p. xxviii.	Enstatite-norite.	
	Q 2.6 di 8.6 or 14.5 hy 19.7 ab 27.3 mt 2.8 an 24.2	Zehner Kopf, Wild Kaar, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXVII, p. 226, 1877. R. T. 1879, p. xliv.	Labradorite-porphyrite.	
	Q 3.3 di 9.8 or 7.2 hy 17.5 ab 36.2 mt 6.7 an 18.4	Zehner Kopf, Wild Kaar, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXVII, p. 227, 1877. R. T. 1879, p. xliv.	Labradorite-porphyrite.	
	or 11.7 di 3.1 ab 29.3 hy 13.8 an 30.3 ol 7.4 mt 3.3	Sobretta, Tyrol.	von John.	Stache and von John, Jb. Wien. G. R-A., XXVII, p. 226, 1877. R. T. 1879, p. xliv.	Labradorite-porphyrite.	
NiO trace Cu trace	or 7.2 di 13.2 ab 20.4 ol 17.6 an 30.3 mt 3.3 ne 6.8 ap 0.9	Mosso, n. Biella, Piedmont.	Cossa.	Cossa, Ricerche Chem. e Micros. 1881, p. 63. R. T. 1884, p. xlii.	Olivine-diabase.	
Cl 0.14	or 12.8 di 18.6 ab 22.5 ol 3.6 an 28.6 mt 10.2 ne 3.7	Lava of Jan. 30, 1865. Lingua Grossa, Mount Etna.	C. W. C. Fuchs.	C. W. C. Fuchs, N. J., 1865, p. 713. R. T. 1869, p. cxxviii.	Dolerite	
	or 7.2 di 10.7 ab 26.2 ol 18.3 an 30.6 mt 2.6 ne 3.7	Ferdinandea Island, Mediterranean.	H. Förstner.	H. Förstner, T. M. P. M., XV, p. 391, 1883. R. T. 1884, p. lxxvi.	Basalt.	In W. T., p. 283, No. 94, andose.
	Q 8.6 di 0.9 or 15.0 hy 8.1 ab 37.7 mt 8.4 an 21.1 il 0.6	Taal Volcano, Luzon, Philippines.	K. Oebbeke.	K. Oebbeke, N. J., B. B., I, p. 481, 1881. R. T. 1884, p. lxx.	Andesite.	
	Q 3.5 di 13.1 or 10.6 hy 10.9 ab 27.8 mt 6.5 an 26.1	Sierra de Mariveles, Luzon, Philippines.	K. Oebbeke.	K. Oebbeke, N. J., B. B., I, p. 471, 1881. R. T. 1884, p. lxx.	Andesite.	
FeS_2 0.16	Q 5.8 di 17.3 or 11.1 hy 2.3 ab 30.4 mt 11.6 an 19.7 hm 0.9	Snow River, North Gippsland, Victoria.	A. W. Howitt.	A. W. Howitt, N. J., 1882, I, p. 416. R. T. 1884, p. xl.	Diabase-porphyrite.	

CLASS II. DOSALANE—Continued.

RANG 3. ALKALICALCIC. ANDASE—Continued.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	49.97	17.01	0.86	5.94	7.75	6.39	5.14	.077	5.08	0.03	0.32	.045	0.10		
A1. I	.833	.167	.006	.082	.194	.114	.083	.008			.004	.003	.001		
2	54.14	13.12	7.20	4.72	5.94	7.34	3.82	0.57	2.78		0.88	trace	trace	100.51	2.578
A2. II	.902	.128	.045	.065	.149	.131	.061	.006			.011	—	—		

RANG 4. DOCALCIC. HESSASE.

1	52.95	19.25	4.57	4.69	4.12	9.12	2.09	2.42	0.71	0.34				100.26	2.875
A3. III	.883	.190	.029	.065	.103	.163	.034	.025							

RANG 4. DOCALCIC. HESSASE.

1	47.54	19.52	4.24	6.95	6.66	11.70	3.09	0.16	—		0.18		0.18	100.22	
A2. II	.792	.191	.026	.097	.167	.209	.050	.002			.002		.003		
2	54.80	17.58	0.97	8.84	4.47	8.22	3.14	1.16	0.94				trace	100.12	2.50
A3. III	.913	.172	.006	.123	.112	.146	.051	.012					—		
3	50.08	18.84	7.05	1.03	6.57	12.37	2.39	0.57	0.80				0.88	100.58	
A3. III	.835	.184	.044	.014	.164	.221	.039	.006					.013		
4	48.88	18.85	2.13	6.62	6.45	11.46	2.93	0.70	2.54					100.56	
A3. III	.815	.185	.013	.092	.161	.205	.047	.007							
5	53.00	17.19	4.78	5.05	4.66	8.08	2.92	1.49	1.35		0.57	0.37	trace	99.46	2.856
A2. II	.883	.169	.030	.070	.117	.145	.047	.016			.007	.003	—		
6	43.19	18.69	7.94	6.07	4.98	9.93	3.50	1.15	1.94	0.23	0.90	0.47	1.72	100.71	3.092
B2. III	.720	.183	.050	.085	.125	.177	.056	.012			.011	.003	.024		
7	53.65	20.77	0.98	7.61	1.57	9.16	3.33	1.61	1.33					100.01	2.82
A3. III	.894	.203	.006	.106	.039	.164	.054	.017							.11°
8	46.71	22.23	0.79	5.46	10.30	11.69	1.70	0.15	1.15					100.18	3.017
A3. III	.779	.218	.005	.076	.258	.209	.027	.002							

CLASS II. DOSALANE.

RANG 1. PERALKALIC. LAURDALASE.

1	54.52	13.37	0.61	3.52	6.37	4.38	1.60	10.73	2.76	1.82				99.58	
A3. III	.909	.131	.004	.049	.159	.079	.026	.114							

ORDER 5. PERFELIC. GERMANARE—Continued.

SUBRANG 5. PERSODIC. BEERBACHOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
Cl 0.03 F 0.10 S 0.12 CuO 0.12 BaO 0.06 Li_2O 0.02	or 4.5 di 8.5 ab 36.2 ol 17.9 an 21.1 mt 1.4 ne 4.0 il 0.6 ap 1.0	Norheim Tunnel, Nahethal, Rhenish Prussia.	Laspeyres.	Laspeyres, Z. D. G. G., XIX, p. 855, 1867. R. T. 1869, p. LXX.	Gabbro.	
	Q 8.9 di 15.3 or 3.3 hy 9.2 ab 32.0 mt 10.4 an 17.0 il 1.7	Säsebuhl, n. Drausfeld, Hanover.	Möhl.	Möhl, N. J., 1874, p. 906. R. T. 1879, p. LXXIV.	Tachylyte.	Near hessose.

SUBRANG 3. SODIPOTASSIC.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 5.8 di 7.2 or 13.9 hy 11.6 ab 17.8 mt 6.7 an 36.4	Monte Mulatto, Predazzo, Tyrol.	Szameit.	G. Tschermak, Porphyrgest. Oester., 1867, p. 127. R. T. 1869, p. LXXVIII.	Melaphyre.	Al_2O_3 high? MgO low?

SUBRANG 4,5. PRESODIC. HESSOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	or 1.1 di 15.8 ab 23.6 ol 13.2 an 38.6 mt 6.0 ne 1.4 il 0.8	Cascade Mountains, Oregon.	Jannasch.	Jannasch and Kloos, T. M. P. M., 1881, p. 102, R. T. 1884, p. LXXIV.	Dolerite.	
	Q 3.1 di 8.6 or 6.7 hy 23.3 ab 26.7 mt 1.4 an 30.8	Ombe Mountains, Nevada.	R. W. Woodward.	C. King, G. Expl. 40th Par., II, p. 500, 1877. R. T. 1879, p. LXXIV.	Basalt.	Near andose.
	Q 2.5 di 17.7 or 3.3 hy 8.2 ab 20.4 mt 3.3 an 38.6 hm 4.8	Doonane Hill, County Donegal, Ireland.	S. Haughton.	S. Haughton, Tr. R. Ir. Ac., XXIV, p. 28, 1866, R. T. 1869, p. LXIV.	Trap (diorite).	Iron oxides?
	or 3.9 di 16.8 ab 24.6 hy 13.4 an 36.4 mt 3.0	N. of Sörskogen, Animskogssocken, Sweden.	Törnebohm.	Törnebohm, Sv. G. Und., XXXIV, p. 31, 1870, R. T. 1873, p. XVIII.	Diorite.	
	Q 6.8 di 6.5 or 8.9 hy 13.0 ab 24.6 mt 7.0 an 29.5 il 1.1 ap 0.9	Schwarzenberg, Vogesen.	L. von Werveke.	H. Rosenbusch, Steiger Schiefer., 1877, p. 334, R. T. 1879, p. XXX.	Quartz-diorite.	Near andose.
	or 6.7 di 11.5 ab 19.9 ol 7.3 an 32.0 mt 11.6 ne 5.1 il 1.7 ap 1.0	Colonat Hervel, Kr. Altena, Westphalia.	von d. Mark.	von d. Mark, Vh. Nh. Ver. Rheinl., XXXV, p. 257, 1878, R. T. 1879, p. LXXIV.	Basalt.	MnO high.
	Q 2.0 di 7.6 or 9.5 hy 13.2 ab 28.3 mt 1.4 an 36.7	Torfhaus, n. Baste, Harz Mountains.	Streng.	Streng, N. J., 1862, p. 963, R. T. 1869, p. LXX.	Gabbro.	
	or 1.1 di 4.5 ab 14.2 hy 6.9 an 52.5 ol 18.8 mt 1.2	Langenlois, Lower Austria.	Beauregard.	Beauregard, T. M. P. M., 1878, p. 369, R. T. 1879, p. XXXVIII.	Forellenstein.	

ORDER 6. LENDOFELIC. NORGARE.

SUBRANG 1. PERPOTASSIC.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
Li_2O trace	or 49.5 ac 1.9 lc 10.9 ns 0.9 ne 4.3 di 17.7 ol 10.0	Point of Rocks, Leucite Hills, Wyoming.	R. W. Woodward.	C. King, G. Expl. 40th Par., II, p. 237, 1877, R. T. 1879, p. LX.	Leucitite.	Near wyomingose; cf. No. 1, wyomingose, W. T. p. 339.

CLASS II. DOSALANE—Continued.

RANG 3. ALKALICALCIC.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp. gr.
1	48.68	18.74	2.67	7.18	3.04	10.24	2.47	6.46	——					99.65	
A3. III.	.811	.183	.017	.100	.076	.183	.040	.069							

RANG 3. ALKALICALCIC.

1	47.17	18.87	5.31	5.66	3.86	10.30	2.69	6.60	——				trace	100.46	
A3. III.	.786	.185	.033	.079	.097	.184	.044	.070					——		

CLASS II. DOSALANE.

RANG 1. PERALKALIC.

1	48.21	18.33	4.29	4.64	1.41	2.77	11.75	5.83	1.97				0.13	99.47	
A3. III.	.804	.180	.027	.064	.035	.050	.190	.062					.002		

CLASS III. SALFEMANE.

RANG 1. PERALKALIC. ROCKALLASE.

1	68.75	5.91	5.81	5.33	0.08	2.11	7.52	4.28	n. d.					100.02	
A3. III	1.146	.058	.036	.074	.002	.038	.121	.046							

CLASS III. SALFEMANE.

RANG 3. ALKALICALCIC. VAALASE.

1	52.82	12.51	9.07	3.98	4.74	8.08	2.58	2.44	0.75	0.21	2.08	0.49		99.75	2.86
A2. II	.880	.122	.057	.053	.119	.145	.042	.026			.026	.004			

RANG 3. ALKALICALCIC. VAALASE.

1	53.39	12.18	6.18	6.70	6.17	6.80	2.70	1.76	2.09	0.28	1.39	0.25		100.13	
A2. II	.890	.119	.039	.093	.154	.121	.044	.019			.017	.002			
2	52.41	13.04	9.46	8.35	3.50	8.36	3.24	1.23	1.26					100.85	
A3. III	.874	.128	.059	.116	.088	.149	.052	.013							

RANG 4. DOCALCIC.

1	49.57	15.56	8.79	4.68	7.09	8.10	2.18	1.07	0.68	0.50	2.15			100.37	2.927
A3. III	.826	.152	.055	.065	.177	.145	.035	.012			.027				15°

ORDER 7. LENFELIC. ITALARE.

SUBRANG 2. DOPOTASSIC.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
Cl 0.17	or 17.8 di 25.3 an 20.6 ol 4.4 lc 16.1 mt 3.9 ne 11.4	Lava of 1871, Mount Vesuvius.	Morawski and Schinnerer.	Morawski and Schinnerer, Vh. Wien. G. R-A., 1872, p. 161. R. T. 1873, p. XL.	Leucitophyre.	Near II. 7. 3. 3.

SUBRANG 3. SODIPOTASSIC.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	or 10.0 di 25.6 an 19.7 ol 2.4 lc 22.7 mt 7.7 ne 12.5	Lava of 1871, Mount Vesuvius.	Morawski and Schinnerer.	Morawski and Schinnerer, Vh. Wien. G. R-A., 1872, p. 161. R. T. 1873, p. XL.	Leucitophyre.	Near II. 7. 2. 3. and II. 7. 3. 2.

ORDER 8. FELDOLENIC. CAMPANARE.

SUBRANG 4. DOSODIC.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
NiO 0.14	or 14.5 ac 12.5 lc 15.7 ns 5.5 ne 33.5 di 11.8 ol 4.5	Katzenbuckel, Odenwald.	H. Rosenbusch.	H. Rosenbusch, Neph. v. Katzenb., Freiburg, 1869, p. 61. R. T. 1869, p. CVIII.	Nephelinite-porphyry.	

ORDER 3. QUARFELIC. ATLANTARE.

SUBRANG 2. DOPOTASSIC.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
CuO 0.23	Q 28.0 ac 16.6 or 25.6 ns 8.5 ab 6.3 di 9.4 hy 5.1	Sidori, Fosso del Gallo, Pantelleria.	H. Förstner.	H. Förstner, Z. K., VIII, p. 179, 1884. R. T. 1884, p. LXVI.	Pantellerite.	In W. T., p. 311. No. 1, III. 3. 1. 2.

ORDER 4. QUARDOFELIC. VAALARE.

SUBRANG 3. SODIPOTASSIC.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
Traces of Cu, Co, Ni, As.	Q 10.0 di 16.9 or 14.5 hy 4.1 ab 22.0 mt 7.0 an 15.0 il 4.0 hm 4.3 ap 1.3	Frauenberg, Breitfirst, Hesse.	F. Knapp.	F. Knapp, Doler. Gest. Frauenb., Würzburg, 1880, p. 15. R. T. 1884, p. LXXII.	Dolerite.	

SUBRANG 4. DOSODIC. VAALOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
SO_3 0.24	Q 8.8 di 14.4 or 10.6 hy 13.1 ab 23.1 mt 9.1 an 15.6 il 2.6	Near Hasserode, Harz Mountains.	Pufahl.	K. A. Lossen, Z. D. G. G., XXXII, p. 212, 1880. R. T. 1884, p. XXXIV.	Quartz-gabbro.	
	Q 7.6 di 19.5 or 7.2 hy 6.6 ab 27.3 mt 13.7 an 17.5	Lion's Head, Capetown, Cape Colony.	W. F. Hillebrand.	Cohen, N. J., 1874, p. 475. R. T. 1879, p. XLII.	Diabase.	Near camptonose. Cf. Nos. 6–8, vaalose, W. T., p. 311.

SUBRANG 4,5. PRESODIC.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 7.6 di 10.8 or 6.7 hy 12.7 ab 18.3 mt 8.8 an 26.4 il 4.1 hm 2.7	Bockenheim, Mainthal.	Hornstein.	Hornstein, Z. D. G. G., XIX, p. 315, 1867. R. T. 1869, p. CXXXII.	Anamesite.	

CLASS III. SALFEMANE—Continued.

RANG 2. DOMALKALIC. KILAUASE.

	iO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	S
	47.56	12.69	5.26	3.35	10.91	8.38	2.33	3.98	2.16	0.88		0.91		99.75	
	.793	.124	.033	.047	.273	.150	.037	.043				.006			
RANG 2. DOMALKALIC. KILAUASE.															
	50.82	9.14	7.33	7.03	7.22	11.63	3.06	1.02	1.74				0.38	99.37	2
	.847	.089	.046	.097	.181	.207	.049	.011					.005		1
RANG 2. DOMALKALIC. KILAUASE.															
	49.86	12.75	3.36	11.38	4.39	8.71	5.25	0.57	2.56		1.33	0.58		100.74	
	.831	.125	.021	.158	.110	.155	.085	.006			.017	.004			
RANG 3. ALKALICALCIC. CAMPTONASE.															
	52.35	15.72	2.90	7.32	7.36	8.98	2.81	1.32	1.35	0.23		0.30		100.64	
III	.873	.154	.018	.101	.184	.161	.045	.014				.002			
	52.00	15.75	3.55	12.84	3.42	7.39	3.37	1.24	0.35	0.11		1.06		101.08	
IV	.867	.154	.022	.178	.086	.132	.055	.014				.008			
	48.60	15.78	3.22	7.21	10.13	8.34	3.77	1.65	1.30			0.11		99.79	2.
III	.810	.154	.020	.100	.253	.149	.061	.018				.001			
	47.53	14.95	6.73	8.04	7.41	8.50	2.98	1.12	1.95			trace	0.73	99.94	
III	.792	.147	.042	.112	.185	.152	.048	.012				—	.010		
	51.56	14.78	5.32	7.01	6.35	8.06	3.27	1.26	1.10	0.46	1.25			100.42	
III	.859	.145	.033	.097	.159	.144	.053	.014			.016				
	50.93	12.80	4.32	8.08	5.94	8.24	3.28	0.77	1.65	0.14	3.17	0.75		100.0 (99.5	
III	.850	.125	.027	.113	.149	.147	.053	.008			.040	.005			
	50.76	14.50	4.26	6.93	6.75	7.55	2.92	0.85	1.78	0.20	3.06	0.16		99. (99	
II	.846	.142	.027	.096	.169	.135	.047	.009			.038	.001			
	49.35	15.71	7.44	6.96	5.71	9.80	2.96	1.31	0.49					9	
III	.823	.154	.047	.097	.143	.175	.048	.014							
	51.41	12.92	2.87	9.29	5.45	11.46	2.92	0.70	0.32		2.61		0.16		
III	.857	.127	.018	.129	.136	.205	.047	.008			.033		.002		

ORDER 5. PERFELIC. GALLARE.

SUBRANG 3. SODIPOTASSIC. LAMAROSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	or 23.9 di 16.5 ab 15.2 ol 15.2 an 12.2 mt 7.7 ne 5.1 ap 8.0	Libsic, N. of Prague, Bohemia.	Plaminek.	Boricky, T. M. P. M., 1878, p. 510. R. T. 1879, p. XLVI.	Mica-picrophyre.	

SUBRANG 4. DOSODIC. KILAUOSE.

	Q 1.1 di 39.7 or 6.1 hy 5.8 ab 25.7 mt 10.7 an 8.1	Kilauea, Hawaii.	Cohen.	Cohen, N. J., 1880, II, p. 41., R. T. 1884, p. LXXX.	Basalt (Pele's hair).	Cf. Nos. 9 and 10, kilauose. W. T., p. 315.

SUBRANG 5. PERSODIC.

	or 3.3 di 25.1 ab 36.7 ol 10.6 an 9.5 mt 4.9 ne 4.3 il 2.6 ap 1.3	South Staffordshire, England.	Henry.	Beete-Jukes, B. G. Soc. Fr., XXIII, p. 121, 1866. R. T. 1869, p. LXXXII.	Greenrock.	

SUBRANG 4. DOSODIC. CAMPTONOSE.

Li_2O trace	Q 1.8 di 14.9 or 7.8 hy 18.7 ab 23.6 mt 4.2 an 26.4	Little Falls, Minnesota.	Streng.	Streng, N. J., 1877, p. 129. R. T. 1879, p. XXXIV.	Augite-diorite.	Near auvergnose.
	Q 1.8 di 4.7 or 7.8 hy 26.8 ab 28.8 mt 5.1 an 23.6 ap 2.7	Richmond, Minnesota.	Streng.	Streng, N. J., 1877, p. 124. R. T. 1879, p. XXXIV.	Augite-diorite.	
	or 10.0 di 16.6 ab 19.9 ol 20.1 an 20.9 mt 4.6 ne 6.5	Navesink Peak, Elkhead Mts., Colorado.	R. W. Woodward.	C. King, G. Expl. 40th Par., I, p. 676, 1878. R. T. 1879, p. LXII.	Nephelite-basalt.	
	or 6.7 di 14.7 ab 25.2 hy 6.6 an 24.2 ol 10.5 mt 9.7	Stichill, Scotland.	J. J. H. Teall.	J. J. H. Teall, N. J., 1884, I, p. 73. R. T. 1884, p. XLII.	Porphyrite.	Not in W. T.
	Q 1.7 di 14.8 or 7.8 hy 15.1 ab 27.8 mt 7.7 an 21.7 il 2.4	Louisa, Mainthal.	Hornstein.	Hornstein, Z. D. G. G., XIX, p. 325, 1867. R. T. 1869, p. CXXXII.	Anamesite.	
Cl 0.01	Q 5.7 di 15.0 or 4.5 hy 13.6 ab 27.8 mt 6.8 an 17.8 il 6.1 ap 1.7	Bühl, n. Weimar, Cassel.	Dietrich.	Möhl, Ber. Offenb. Ver. Nk., 1868, p. 77. R. T. 1869, p. CXXXII.	Anamesite.	Sum given as 99.505.
SO_3 0.08	Q 5.8 di 10.9 or 5.0 hy 15.8 ab 24.6 mt 6.8 an 23.9 il 5.8	Bühl, n. Weimar, Cassel.	Dietrich.	Möhl, Ber. Offenb. Ver. Nk., 1868, p. 77. R. T. 1869, p. CXXXII,	Anamesite.	Sum given as 99.69.
	or 7.8 di 18.7 ab 25.2 hy 9.9 an 25.6 ol 1.4 mt 10.9	Cuddie Monti, Pantelleria.	Förstner.	Förstner, T. M. P. M., 1883, p. 393. R. T. 1884, p. LXXVI.	Basalt.	Not in W. T.
	Q 1.6 di 28.0 or 4.5 hy 10.2 ab 24.6 mt 4.2 an 22.8 il 5.0	Lava of 1843, Kilauea, Hawaii.	Cohen.	Cohen, N. J. 1880, II, p. 41. R. T. 1884, p. LXXX.	Basalt obsidian.	Near ornose.

CLASS III. SALFEMANE—Continued.

RANG 3. ALKALICALCIC. CAMPTONASE—Continued.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	53.81	13.48	3.02	7.39	6.46	10.34	3.23	0.64	0.57		2.01		trace	100.95	2.75
B2. III	.897	.132	.019	.103	.162	.185	.052	.007			.025				17°
2	51.12	10.09	5.35	8.59	9.68	9.72	3.38	0.56	1.31				——	99.80	2.73
A3. III	.852	.099	.034	.119	.242	.173	.055	.006							16°
3	50.74	11.98	3.41	8.11	7.25	12.42	2.74	0.24	0.52		1.68		0.54	99.63	2.98
A2. II	846	.118	.021	.113	.181	.221	044	.002			.021		.008		

RANG 4. DOCALCIC. AUVERGNASE.

1	49.18	13.52	5.52	10.31	6.83	11.51	1.84	0.06	0.34		0.52	0.13	0.28	100.04	3.016
A2. II	.820	.132	.034	.143	.171	.205	.030	.001			.007	.001	.004		
2	48.04	13.13	6.89	11.14	5.17	10.87	2.83	0.06	——		0.39	0.07	0.11	100.72	3.024
A2. II	.801	.129	.043	.155	.154	.195	.045	.001			.005	.001	.002		
3	52.68	14.14	1.95	9.79	6.38	9.38	2.56	0.87	1.60				0.44	99.79	2.97
A3. III	.878	.137	.013	.136	.160	.168	.042	.009					.006		
4	52.42	14.54	1.25	9.84	7.53	10.59	2.23	0.49	0.55				0.51	99.75	3.00
A3. III	.874	.142	.008	.137	.188	.189	.035	.005					.007		
5	51.78	14.20	3.59	8.25	7.63	10.70	2.14	0.39	0.63			0.14	0.44	99.89	3.03
A3. III	.863	.139	.023	.115	.191	.191	.034	.004				.001	.006		
6	53.13	13.74	1.08	9.10	8.58	9.47	2.30	1.03	0.90				0.43	99.76	2.96
A3. III	.886	.135	.007	.126	.215	.170	.037	.011					.006		
7	49.67	13.57	7.79	7.21	5.53	12.37	1.57	1.20	0.15		1.50			100.56	2.958
A3. III	.828	.133	.049	.100	.138	.221	.026	.013			.019				
8	49.63	16.18	1.92	12.03	5.38	9.33	1.89	0.81	0.55		1.75	0.44	0.30	100.66	3.02
A1. I	.827	.159	.012	.167	.145	.166	.031	.008			.022	.003	.004		16°
9	47.36	16.79	1.53	7.93	6.53	10.08	2.85	0.84	3.05	0.48	0.51	0.26	0.44	100.61	3.081
A2. II	.799	.165	.009	.110	.163	.180	.046	.009			.006	.002	.006		
10	45.93	15.09	1.87	11.45	14.82	8.92	1.93	0.22	0.58					100.81	
A3. III	.766	.148	.012	.159	.371	.159	.031	.002							
11	49.87	14.80	8.25	6.88	6.77	9.36	2.81	0.68	0.45					99.87	
A3. III	.831	.145	.052	.096	.169	.167	.045	.007							
12	50.75	16.54	2.10	7.88	7.65	11.96	2.13	0.56	0.35					99.92	
A3. III	.846	.162	.013	.110	.191	.214	.034	.006							

ORDER 5. PERFELIC. GALLARE—Continued.

SUBRANG 5. PERSODIC. ORNOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	Q 3.8 or 3.9 ab 27.3 an 20.3 di 25.2 hy 11.8 mt 4.4 il 3.8	Kilauea, Hawaii.	Cohen.	Cohen, N. J., 1880, II, p. 41. R. T. 1884, p. LXXX.	Basalt-obsidian.	Near camptonose.
	or 3.3 ab 28.8 an 10.6 di 30.3 hy 30.3 ol 7.9 mt 7.9	Lava of 1868, Mauna Loa, Hawaii.	Cohen.	Cohen, N. J., 1880, II, p. 41. R. T. 1884, p. LXXX.	Basalt-pumice.	
	Q 1.5 or 1.1 ab 23.1 an 20.0 di 33.5 hy 11.3 mt 4.9 il 3.2	Lava of April, 1867, Niuafou, Tonga Islands.	von Werveke.	Cohen, N. J., 1880, II, p. 41. R. T. 1884, p. LXXX.	Basalt-obsidian.	

SUBRANG 4,5. PRESODIC. AUVERGNOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
Cl trace Cu trace	Q 3.3 or 0.6 ab 15.7 an 28.1 di 23.7 hy 18.9 mt 7.9 il 1.1	Brededal, Disco, Greenland.	Nauckhoff.	Nauckhoff, T. M. P. M., 1874, p. 120. R. T. 1879, p. LXXIV.	Basalt.	
Cl trace S 0.98 C 0.79 H? 0.25	Q 0.4 or 0.6 ab 23.6 an 23.1 di 25.5 hy 14.4 mt 10.0 il 0.8 pr 1.8	Ovifak, Greenland.	Nauckhoff.	Nauckhoff, T. M. P. M., 1874, p. 121. R. T. 1879, p. LXXIV.	Basalt.	
	Q 2.1 or 5.0 ab 22.0 an 23.9 di 18.9 hy 22.9 mt 3.0	Mount Holyoke, Massachusetts.	G. W. Hawes.	G. W. Hawes, A. J. S. (3), IX, p. 186, 1875. R. T. 1879, p. XLII.	Dolerite (diabase).	
	Q 1.6 or 2.8 ab 18.3 an 28.4 di 19.9 hy 26.0 mt 1.9	Wintergreen Lake, New Haven, Connecticut.	G. W. Hawes.	G. W. Hawes, A. J. S. (3), IX, p. 189, 1875. R. T. 1879, p. XLII.	Dolerite (diabase).	
	Q 3.5 or 2.2 ab 17.8 an 28.1 di 20.4 hy 21.4 mt 5.3	West Rock, New Haven, Connecticut.	G. W. Hawes.	G. W. Hawes, A. J. S. (3), IX, p. 186, 1875. R. T. 1879, p. XLII.	Dolerite (diabase).	
	Q 0.4 or 6.1 ab 19.4 an 24.2 di 18.9 hy 28.0 mt 1.6	Jersey City, New Jersey.	G. W. Hawes.	G. W. Hawes, A. J. S. (3), IX, p. 187, 1875. R. T. 1879, p. XLII.	Dolerite (diabase).	
	Q 6.5 or 7.2 ab 13.6 an 26.1 di 28.2 hy 4.5 mt 11.4 il 2.9	Thiorsa, Iceland.	S. von Waltershausen.	S. von Waltershausen, Abh. Ges. Wiss. Gött., X, p. 23, 1862. R. T. 1869, p. CXXXVI.	Anorthite rock.	Mean of several.
F trace S 0.07 Cr_2O_3 0.38 CuO trace	Q 2.3 or 4.5 ab 16.2 an 33.4 di 8.3 hy 27.9 mt 2.8 il 3.3 ap 1.0	Radauthal, Harz Mountains.	Streng.	Streng, N. J., 1862, p. 966. R. T. 1869, p. LXX.	Gabbro.	
Cl trace FeS_2 1.96	or 5.0 ab 24.1 an 30.6 di 15.9 hy 3.4 ol 12.9 mt 2.1 il 0.9 pr 2.0	Lupbode, Harz Mountains.	Kayser.	Kayser, Z. D. G. G., XXII, p. 159, 1870. R. T. 1873, p. XXIV.	Diabase.	Not fresh.
	or 1.1 ab 16.2 an 32.0 di 9.9 hy 2.9 ol 35.3 mt 2.8	Ottenschlag, Austria.	Gamroth.	Gamroth, T. M. P. M., 1877, p. 278. R. T. 1879, p. XLVI.	Paleopicrite.	
	Q 2.8 or 3.9 ab 23.6 an 25.9 di 16.5 hy 14.8 mt 12.1	San Marco, Pantelleria.	Förstner.	Förstner, T. M. P. M., 1883, p. 393. R. T. 1884, p. LXXVI.	Basalt.	Not in W. T.
	or 3.3 ab 17.8 an 33.9 di 20.9 hy 18.6 ol 1.3 mt 3.0	Kilauea, Hawaii.	Allen.	J. D. Dana, A. J. S. (3), XVIII, p. 134, 1879. R. T. 1884, p. LXXX.	Basalt (Pele's hair).	

CLASS III. SALFEMANE—Continued.

RANG 3. ALKALICALCIC. LIMBURGASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	43.60	11.76	7.84	15.38	3.33	10.32	3.42	1.36	1.00		0.82		0.23	99.06	2.842
B2. III	.727	.115	.055	.214	.083	.184	.055	.015			.010		.003		
2	41.01	11.58	12.54	7.60	8.67	12.20	2.57	1.45	1.87		0.48	0.75		100.72	3.024
A2. II	.684	.113	.078	.106	.217	.218	.042	.016			.006	.005			
3	41.97	15.83	6.06	8.38	15.81	6.32	2.64	1.55	1.08		0.02		0.23	99.89	
A3. III	.700	.154	.038	.117	.395	.113	.042	.017			—		.003		

RANG 4. DOCALCIC.

1	41.33	18.31	8.52	6.10	8.40	11.76	2.34	1.01	1.63					99.40	
A3. III	.689	.179	.053	.085	.210	.210	.038	.011							

CLASS III. SALFEMANE.

RANG 1. PERALKALIC. MALIGNASE.

1	46.97	14.55	8.79	6.02	1.40	9.46	8.18	3.07	1.53					99.97	
A3. III	.783	.142	.055	.083	.035	.169	.132	.033							

RANG 2. DOMALKALIC. KAMERUNASE.

1	45.04	16.04	7.10	8.23	4.46	10.19	6.11	2.85	0.33					100.35	
A3. III	.751	.157	.044	.114	.112	.182	.098	.031							
2	42.65	15.35	6.46	8.19	7.14	11.96	5.02	1.47	1.28					99.52	
A3. III	.711	.150	.040	.114	.179	.214	.081	.016							

RANG 3. ALKALICALCIC. ETINDASE.

1	40.53	14.89	1.02	11.07	8.02	14.62	2.87	1.95	1.44	0.17	1.80	1.32	0.16	99.86	3.043
A2. II	.676	.146	.006	.154	.201	.261	.047	.021			.023	.009	.002		18°

CLASS III. SALFEMANE.

RANG 2. DOMALKALIC. ALBANASE.

1	41.24	15.28	4.64	9.09	8.69	12.97	3.66	3.64	0.92					100.13	
A3. III	.687	.150	.029	.126	.217	.232	.059	.038							

RANG 2. DOMALKALIC. ALBANASE.

1	39.64	16.98	6.61	9.31	6.65	10.58	5.95	3.09	1.32					100.13	
A3. III	.661	.166	.041	.129	.166	.189	.096	.033							

ORDER 6. LENDOFELIC. PORTUGARE.

SUBRANG 4. DOSODIC. LIMBURGOSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
	or 8.8 di 33.0 ab 14.7 ol 8.3 an 12.5 mt 12.8 ne 7.7 il 1.5	Scheidsberg, Remagen, Rhenish Prussia.	Möhl.	Möhl, N. J., 1874, p. 203. R. T. 1879, p. LXXII.	Anamesite.	
	or 9.0 di 32.0 ab 7.3 ol 6.8 an 15.3 mt 18.1 ne 8.0 il 0.9 ap 1.7	Sparbrod, Rhöngebirge.	Sommerlad.	Sommerlad, N. J. B. B., II, p. 155, 1882. R. T. 1884, p. LXXIV.	Hornblende-basalt.	
	or 9.5 di 4.0 ab 7.3 ol 35.6 an 26.4 mt 8.8 ne 8.0	Philip Island, Victoria, Australia.	Selwyn and Ulrich.	Selwyn and Ulrich, Geog. Phys. Vict., 1866, p. 59. R. T. 1869, p. CXII.	Basalt.	

SUBRANG 4,5. PRESODIC.

	or 6.1 di 17.6 ab 6.3 ol 12.0 an 36.1 mt 12.3 ne 7.4	Weilberg, Nassau.	v. Gerichten.	v. Gerichten, N. J., 1874, p. 740. R. T. 1879, p. LXXVI.	Basalt.	

RANG 7. LENFELIC. KAMERUNARE.

SUBRANG 4. DOSODIC. MALIGNOSE.

	or 18.4 ac 10.6 ab 2.6 di 20.0 ne 29.5 wo 9.6 mt 7.4	Katzenbuckel, Odenwald.	H. Rosenbusch.	H. Rosenbusch, Neph. Katzenb., Freiburg, 1869, p. 39. R. T. 1869, p. CVI.	Nephelinite.	

SUBRANG 4. DOSODIC. KAMERUNOSE.

	or 17.2 di 35.3 an 7.8 ol 2.2 ne 27.8 mt 10.2	Upper Picos Valley, Santiago, Cape Verde Islands.	Kertscher.	C. Doelter, Die Capverden, 1882, p. 79. R. T. 1884, p. LXXXII.	Augitite.	
	or 3.3 di 36.4 an 14.7 ol 7.2 lc 4.4 mt 9.3 ne 23.0	Upper Picos Valley, Santiago, Cape Verde Islands.	Kertscher.	C. Doelter, Die Capverden, 1882, p. 49. R. T. 1884, p. LXXIV.	Basalt.	

SUBRANG 4. DOSODIC. ETINDOSE.

Traces of Cl, F, S, Cr_2O_3, NiO, and BaO.	an 21.7 di 19.3 lc 9.2 ol 19.9 ne 13.4 am 6.9 mt 1.4 il 3.5 ap 3.0	Rossberg, n. Rossdorf, Hesse-Darmstadt.	Petersen.	Petersen, N. J., 1869, p. 36. R. T. 1869, p. CXII.	Basalt.	

ORDER 8. FELDOLENIC. BOHEMARE.

SUBRANG 3. SODIPOTASSIC.

	an 14.7 di 1.6 lc 16.6 ol 24.5 ne 16.8 am 17.4 mt 6.7	Herchenberg, Laacher See, Rhenish Prussia.	Rammelsberg.	Rammelsberg, priv. contrib., 1872. R. T. 1873, p. XLIV.	Nephelinite.	Calc. from sol. and insol.

SUBRANG 4. DOSODIC. COVOSE.

	an 10.3 di 6.4 lc 14.4 ol 18.3 ne 27.3 am 12.5 mt 9.5	St. Vincent, Cape Verde Islands.	Kertscher.	C. Doelter, Die Capverden, 1882, p. 15. R. T. 1884, p. XLII.	Olivine-diabase.	

CLASS III. SALFEMANE—Continued.

RANG 1. PERALKALIC. IJOLASE.

No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	CO_2	TiO_2	P_2O_5	MnO	Sum	Sp.gr.
1	45.04	11.35	13.92	4.89	4.62	7.86	7.86	2.93	1.52		trace	0.12	0.18	100.29	3.096
A2. II	.751	.111	.087	.068	.116	.140	.127	.031				.001	.003		25.5°
2	44.80	11.11	9.82	5.83	4.88	9.55	6.75	3.67	2.96			0.45	0.12	99.94	2.843
A2. II	.747	.109	.061	.081	.122	.171	.109	.039				.003	.002		22.5°

CLASS IV. DOFEMANE.

RANG 1. PERMIRLIC. CORTLANDTASE. SECTION 1. PERMIRIC. CORTLANDTIASE.

1	40.79	10.41	3.52	6.39	23.34	8.48	1.71	0.71	4.04	trace				99.39	
A3. III	.680	.102	.022	.089	.584	.152	.027	.007							

CLASS IV. DOFEMANE.

RANG 1. PERMIRLIC. PAOLASE. SECTION 2. DOMIRIC.

1	42.68	9.42	11.55	7.23	10.09	13.15	2.71	1.16	1.06		0.51	1.29		100.85	3.114
A2. II	.711	.092	.072	.100	.252	.235	.043	.012			.006	.009			

CLASS IV. DOFEMANE.

RANG 1. PERMIRLIC. TEXASE. SECTION 2. DOMIRIC. UVALDIASE.

1	39.59	12.25	10.15	4.69	14.50	14.13	1.89	0.76	0.57	0.89			trace	99.55	3.15
A8. III	.660	.120	.064	.065	.363	.252	.031	.008					—		

ORDER. 9. PERLENIC. FINNARE.

SUBRANG 4. DOSODIC. IIVAAROSE.

Inclusive.	Norm.	Locality.	Analyst.	Reference.	Author's name.	Remarks.
SO_3 trace SrO trace	or 2.5 lc 11.6 ne 23.0 ac 21.3 di 31.1 ol 0.2 mt 9.5	Katzenbuckel, Odenwald.	H. Rosenbusch.	H. Rosenbusch, Nephel. Katzenb., Freiburg, 1869, p. 39. R. T. 1869, p. CVI.	Nephelinite.	Nearly in dofemane.
	lc 17.0 ne 19.9 ac 18.0 di 23.3 ol 6.3 am 6.9 mt 5.1	Katzenbuckel, Odenwald.	H. Rosenbusch.	H. Rosenbusch, Nephel. Katzenb., Freiburg, 1869, p. 65. R. T. 1869, p. CVIII.	Nephelinite.	Nearly in dofemane.

ORDER 1. PERPOLIC. HUNGARARE. SECTION 4. DOMOLIC.

SUBRANG 2. DOMAGNESIC. CUSTEROSE.

	or 2.8 an 18.9 lc 0.9 ne 7.7 di 18.4 ol 41.6 mt 5.1	Gümbelberg, Neutitschein, Moravia.	Jubasz.	G. Tschermak, Porphyrg. Oestr., 1869, p. 247. R. T. 1869, p. LXXXVI.	Picrite.	

ORDER 2. DOPOLIC. SCOTARE. SECTION 2. DOPYRIC. PAOLIARE.

SUBRANG 2. DOMAGNESIC.

	or 6.7 ob 11.5 an 10.0 ne 6.3 di 36.9 ol 7.6 mt 16.7 il 0.9 ap 3.0	Todtenkopfchen, Rhöngebirge.	H. Sommerlad.	H. Sommerlad, N. J. B. B., II, p. 155, 1882. R. T. 1884, p. LXXIV.	Hornblende-basalt.	In W. T., p. 359. No. 4. IV. 2^3. 1^2.2. Mol. ratio of Fe_2O_3 in W. T. wrong, also norm. Correct here.

ORDER 2. DOPOLIC. SCOTARE. SECTION 3. PYROLIC. TEXIARE.

SUBRANG 2. DOMAGNESIC. UVALDOSE.

Cr_2O_3 0.13 NiO trace	an 22.5 lc 3.5 ne 8.8 di 27.4 ol 16.5 am 4.4 mt 14.8	Ottendorf, Silesia.	Scharizer.	Scharizer, Jb. Wien. G. R-A., XXXII, p. 475, 1882. R. T. 1884, p. LXIV.	Nephelite-basalt.	

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ERRATA IN PROFESSIONAL PAPER NO. 14.

I take advantage of this opportunity to call attention to a number of corrections which must be made in Professional Paper No. 14, for some of which I have to thank several friends. While the majority may be regarded as of slight importance, yet those which affect the norms and the classificatory positions of several rocks should be carefully noted. The most important changes in position are:

No. 12 umptekose, p. 253, should be No. 18*a* laurdalose, p. 297.
No. 2 vulturose, p. 305, should be No. 2 II.8.2.4., p. 307.
No. 2 vesuvose, p. 307, should be No. 4 braccianose, p. 305.
No. 1 paolose, p. 361, should be No. 1, subrang 2 of section 3 of texase, p. 363.

I may add once more that I shall consider it a very great favor to be informed of any errors or omissions either in Professional Paper No. 14, or in the present work, so that the proper corrections may be incorporated in a subsequent paper.

Page 23, line 6 from bottom, *for* miaskares *read* miaskases.
Page 34, lines 7 and 9 from bottom, *for* one-ninth *read* one-tenth.
Page 34, line 5 from bottom, *for* one-tenth *read* one-ninth.
Page 83, line 6, *dele* femic.
Page 84, lines 7, 8, 9 from bottom, *for* q *read* 60q.
Page 85, lines 10–14 and 19–23, *for* r *read* (r+u); *for* s *read* (s+v).
Page 85, lines 19–24, *for* Rang *read* Subrang.
Page 90, line 10, *for* 436 *read* 462.
Page 104, line 7 from bottom, *after* silica *insert* and soda with decreasing silica.
Page 112, Femic Subrangs, *for* NgO *read* MgO.
Page 139, No. 1 riesenose, Author's name col., *insert* Porphyry.
Page 195, No. 3 nordmarkose, Remarks col., *insert* phlegrose.
Page 199, No. 4 vulsinose, Remarks col., *for* syenase *read* nordmarkase.
Page 207, No. 3 canadase, Remarks col., *for* A.G. *read* J.G.
Page 226, heading, Fe_2O_3 col., *for* Fe_2O_2 *read* Fe_2O_3.
Page 232, No. 21 tonalose, Sp. gr. col., *place* 16° *under* 2.740.
Page 244, No. 115 tonalose, H_2O col., *for* 0.52 *read* 0.36.
Page 245, No. 119 tonalose, Norm col., *for* di 17 *read* di 17.6.
Page 253, No. 1 umptekose, Norm col., *for* ne 9.9 *read* ne 9.4.
Page 253, No. 12 umptekose, Norm col., *for* ab 52.4 *read* ab 46.1.
for ne 5.7 *read* ne 9.1.
(This should be No. 18*a* laurdalose.) *after* ns 4.7 *insert* di 7.2.
for ol 4.0 *read* ol 1.5.
for il 3.4 *read* il 3.3.
Page 253, No. 13 umptekose, Norm col., *for* am *read* an.

Page 253, No. 14 umptekose, Reference col., *for* V.R.S. *read* P. R. S.
Page 255, No. 1 ciminose, Norm col., *for* am *read* an.
Page 255, No. 6 ciminose, Reference col., *for* V.G. *read* J.G.
Page 257, No. 12 monzonose, Locality col., *for* Indian Creek laccolith *read* Electric Peak.
Page 261, No. 14 akerose, Locality col., *for* Fairvew *read* Fairview.
Page 279, No. 65 andose, Norm col., *for* an 22.2 *read* an 19.5.
for di 9.0 *read* di 11.0.
(The position of this rock is not changed by these corrections.) *for* hy 7.9 *read* hy 10.7.
for ol 7.2 *read* ol 5.9.
Page 295, heading, *insert* 3 *after* Subrang.
Page 298, No. 7 essexose, CaO col., *for* 1.31 *read* .131.
Page 298, No. 12 essexose, MgO col., *for* 1.11 *read* .111.
Page 304, No. 2 vulturose, CaO col., *for* .106 *read* .155.
Page 305, No. 2 vulturose, Norm col., *for* or 19.5 *read* or 4.5.
for lc 6.1 *read* lc 17.9.
(This should be No. 2 II.8.2.4.) *for* di 13.9 *read* di 23.0.
for ol 8.2 *read* ol 3.7.
Page 307, No. 2 vesuvose, Norm correct, but should be No. 4 braccianose, p. 305.
Page 317, No. 8 kentallenose, Locality col., *for* Indian Creek laccolith *read* Electric Peak.
Page 317, No. 10 kentallenose, Reference col., *for* 1698 *read* 168.
Page 329, No. 21 ornose, Locality col., *for* Koolan *read* Koolau.
Page 345, No. 1 III.6.4.2, Remarks col., *after* and 6 *insert* limburgose.
Page 349, catch title, *for* SR3 *read* SR2.
Page 351, No. 1 III.7.3.5, Author's name col., *for* nepholite *read* nephelite.
Page 351, No. 1 III.8.2.3, Norm col., *for* an 10.2 *read* am 10.2.
Page 353, No. 1 covose, Norm col., *for* di 12.6 *read* di 12.5.
for am 6.1 *read* am 17.8.
dele wo 10.3.
Page 353, No. 2 covose, Norm col., *for* di 6.8 *read* di 15.9.
for ol 8.4 *read* ol 5.3.
for am 11.2 *read* am 17.0.
dele wo 11.8.
Page 353, No. 5 covose, Norm col., *for* di 18.0 *read* di 21.0.
for ol 1.9 *read* ol 1.0.
for am 2.8 *read* am 6.5.
dele wo 5.7.
Page 353, No. 6 covose, Norm col., *for* di 32.4 *read* di 35.0.
for am 1.2 *read* am 2.4.
dele wo 2.9 *and* ol 0.9.
Page 355, catch title, *for* salfemane *read* dofemane.
Page 361, No. 1 paolose, Norm col., *for* di 21.8 *read* di 27.4.
for ol 7.3 *read* ol 5.5.
(This should be IV.2^3.1^3.2.) *for* am 10.8 *read* am 17 8.
dele wo 11.4.
Page 412, No. 1 porphyrite, Sum col., *insert* 100.55.
Page 418, No. 3 andesite, No. col., *for* B4 *read* D4.
Page 455, Nos. 80 and 81 basalt, Locality col., *for* Panahou *read* Punahou.
Page 489, Ciminite, *for* 261 *read* 259.
Page 490, Granite, inclusion in, *insert* 145, *for* 263 *read* 261.
Page 490, Granite, segregation in, *insert* 145.
Page 490, Hornblende-basalt, *insert* 359, *for* 459 *read* 455.
Page 491, Pantellerite, *after* 219 *insert* 221.
Page 494, Greece, *after* 249 *insert* 251.

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